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Wide World Photos

MARIE CURIE

EDITOR'S OUTLOOK

Marie Sklodowska Curie

WHEN Madame Curie addressed the assembly at St. Lawrence University on the opening of Hepburn Hall (see THIS JOURNAL, p. 268) doubtless her words, clothed in the brevity and directness that characterize all her public utterances, rose from a full heart, for it is probable that the one regret which this distinguished woman attaches to the years she has given to science centers on the difficulties imposed upon her work by the lack of adequate facilities in the early period of her researches. These hindrances postponed her various discoveries by months, and in the aggregate by years, but the fact that such obstacles present no permanent barrier to the zealous investigator can never be more perfectly demonstrated than in the career of Madame Curie.

Marie Sklodowska was born in Warsaw on November 7, 1867, of cultivated Polish forebears. Her youth was spent in an atmosphere of national indignation against foreign domination, and from the moral warfare that resulted and that was nowhere more evident than in the schools, she early learned the necessity of struggle for the things of life that are most to be desired. Her early training in the schools of Poland was under the supervision of her father, a professor of physics and mathematics, who, himself deprived of the opportunity to pursue research, eagerly cultivated in his children their strong natural bent to science. After the completion of her preliminary training, there ensued a period of self-support by private tutoring and of self-development by independent study in science, which made up in personal discipline what it lacked in material progress. Her inherited intellectual tastes not only survived this trying interim, but indeed took new life from it, so that her twenty-fifth year found her a student at the *Faculté des Sciences* in Paris, from which she obtained after a four-year course the degree of licentiate in physics and in mathematics.

Throughout her student life in Paris, her extremely limited means forced her to the utmost privations, but the intellectual hunger that drove her more persistently than physical necessities was the charm that attracted to her the young physicist, Pierre Curie, whom she married in 1895. An ambition to social service which she had carried out of her youth in Poland had to be laid aside in this marriage, which was nevertheless based on a common aspiration and needs no further commentary than the words with which Pierre Curie, when the gradual accumulation of domestic cares threatened the continuance of his wife's scientific pursuits, swept away the possibility of such a catastrophe. "I have got," he said, "a wife made expressly for me to share all my preoccupations." Dr. Curie had been newly appointed to the chair of physics at the School of Physics and Chemistry of the city of Paris, and it was the young wife's happiness to be permitted to carry on her studies

for a doctorate in science in a miserable room of the school which was all that could be provided for their laboratory. She entered avidly into further investigation of the phenomenon of uranium emissions, observed by Becquerel a short time before, and in the ensuing five years, with a patience and assiduity characteristic of the feminine genius, if not peculiar to it, examined for the property of radiation all the elements then known. During this process of elimination, it became apparent that in the minerals under investigation other unknown elements must be present in proportions so minute as to defy detection under ordinary means of analysis. Consequently, Madame Curie, in association with her husband, subjected them to electroscopic examination, a method used by Becquerel, which was to become in the hands of the Curies the instrument of the new science of radioactivity. By the year 1898, Madame Curie was ready to present to the world the discovery of polonium and radium. However, to indicate the existence of these through their properties and compounds was one thing; to isolate them was another matter, and the Curies began to feel keenly the absence of financial aid in furthering their work. The necessity of additional space in which to handle the great supplies of primitive ore which yielded the small workable quantities of salts of the new elements was met with the surrender to the researchers of an abandoned shed in the School of Physics and Chemistry. In this wretched environment, barren even of the ordinary conveniences of existence, much less the particular necessities of careful scientific work, the Curies lived nevertheless in its fulness the poet's line,

> He whom a dream hath possessed knoweth no more of doubting,

for in her memoirs Madame Curie testifies that they passed here the best and happiest years of their lives. In 1902, Madame Curie positively established the existence and character of radium. In the following year she received her doctor's degree and shared with her husband and Henri Becquerel the honors and emoluments of the Nobel award in physics.

Immediate and world-wide recognition met the announcement of these important discoveries; nothing succeeds like success, and the material aid that would have eased and expedited their labors was readily extended to the Curies now, but they had only a brief two years in which to make much of it together. In 1906, by the death of Pierre Curie in an accident, the eleven years of perfect companionship were abruptly terminated. The Sorbonne honored his widow by placing her in charge of the course under the chair of physics which had been newly created for him, and several years later she was appointed to his titular professorship. Her research continued. In 1911, the only woman who has ever received the Nobel award in science became the only scientist who has

ever received it twice. This time it came in the field of chemistry "in recognition of the services rendered by her to the development of chemistry, by her discovery of the elements radium and polonium, by her determination of the nature of radium, and isolation of it in a metallic state, and by her investigation into the compounds of this remarkable element."

While the Curies and their associates had been penetrating the new science of radioactivity, the practical applications of radium had come to gradual recognition and the outbreak of the war in 1914 gave a new and unlooked-for impetus to the use of radium in therapy. With this development began a new life for Madame Curie. The Curie family had remained for many years in comparative isolation, and the publicity resulting from their discoveries, while it carried relief from many burdens, was painfully subversive of their chosen mode of living. But the war had a various appeal to Madame Curie. To the woman in her it offered an immediate and pressing need awaiting relief at her hand; to the patriot and nationalist it spoke of hope and fear for her native land and for the country of her adoption; to the scientist it gave an unprecedented opportunity to put to proof the human value of her life work. The retiring student became the woman of affairs. New gifts of organization and administration were born in her. New powers of physical endurance came to life and, throughout the war, she was a familiar and welcome figure at the hospitals of the front and behind the lines, bringing to the medical profession an instrument unused hitherto in the care of the wounded, installing radiological apparatus, instructing the unskilled in its use, and at the same time building up at home a corps of experienced manipulators for the needs of the service.

Since the close of the war, with unflagging energy Madame Curie has utilized her invaluable experience in the conduct of the Radium Institute established by the University of Paris, in collaboration with the radiological work of her native city, Warsaw, and, in general, in the multiple activities which have grown out of her discoveries. An aging woman now, she has lived to view with satisfaction the attainment of her youthful ideal of social helpfulness through the very science to which, in regretfully surrendering that ambition, she diverted the stream of her life.

The Journal gratefully acknowledges its indebtedness to L. Razet, secretary of the Radium Institute, Paris, for portions of the material used in this biographical sketch.

SO MANY agencies have held forth illusory promises of the abolition of war that new guarantors of perpetual peace are likely to be received somewhat skeptically, even if wistfully. Has Dr. Millikan, in

Science as Peacemaker

his recent presidential address to the American Association for the Advancement of Science, added himself to the company of those who make glowing and ill-considered claims for the potentialities of science or has he in truth indicated one of the logical consequences of the present trend of our civilization?

On the rôle of science in the eventual abolition of war *The New York Times* quotes him as follows:

> Steel does indeed make bayonets, but it also makes plowshares and railroads and automobiles and sewing machines and threshers and a thousand other things whose uses constitute the strongest existing diverter of human energies from the destructive to the peaceful arts.
>
> In my judgment, war is now in process of being abolished, chiefly by this relentless advance of science, its most powerful enemy. It has existed in spite of religion, and in spite of philosophy, and in spite of social ethics, and in spite of the Golden Rule, since the days of the cave man because, in accordance with the evolutionary philosophy of modern science, and simply because it has had survival value.
>
> It will disappear like the dinosaur when, and only when, the conditions which have given it survival value have disappeared, and those conditions are disappearing now, primarily because of changes in the world situation being brought about by the growth of modern science.

One could wish that Dr. Millikan had discussed this subject in more detail, or, if he did so, that he had been reported more completely. His statement, as it stands, is neither conclusive nor very informative, but it is, without doubt, provocative of thought.

One is immediately tempted to try to get at the meat of Dr. Millikan's idea, because of its conspicuous negative virtues. It is free of the wishful optimism which anticipates a millenium induced by any abnormal improvement in international ethics. It tacitly recognizes diplomats and governments for the scheming, dishonest seekers of advantage, which every successive war has shown them to be, and it accepts the fact that their treaties and pledges are no more than handfuls of dust which they throw in each other's eyes.

Stated positively, Dr. Millikan's underlying idea is that if nations are ever to abolish war permanently it must be through the influence of "enlightened self-interest." If there is a note of unwarranted optimism in the prediction that science will bring this influence to bear, it is indicated by the observation that whereas nations, like individuals, are unanimously and whole-heartedly committed to self-interest, they are, again like individuals, notoriously insusceptible to enlightenment. Surely warfare has been a highly unprofitable undertaking, even for the victors, for the past century. Are we to understand that science will in some mysterious manner raise the general intelligence to the

level where it will be capable of perceiving that fact? We cannot believe that Dr. Millikan had anything so naïve in mind.

If we judge him aright he pins his hopes for peace on the axiom that the man of property is always a conservative—a supporter of law and order. The solid and prosperous citizen has all to lose by violence and nothing to gain. He is not likely to undertake campaigns of aggression and it is hard to arouse him to holy causes which may endanger his holdings. Dr. Millikan reasons, no doubt, that the psychology of nations is somewhat similar to the psychology of individuals, and he perceives that the application of science bids fair to make substantial property holders out of all the leading nations.

Perhaps he had in mind also the fact that the development of new sources or processes of production for essential commodities, and the synthesis of new and ofttimes better substitutes for old commodities will tend to make nations more self-supporting. The removal of acute fears occasioned by conspicuous lacks in natural resources will doubtless go far toward restraining a hysterical tendency to grab whenever the grabbing seems exceptionally good.

Thus while science will certainly continue to make peace more and more profitable and while it may be expected to alleviate some of the conditions which naturally lead to war, it will also continue to make war more and more unprofitable. By this we do not mean that war will become so horrible or so destructive that nations will hesitate to engage in it.

There has been so much loose thinking and talking on this point that it seems justifiable to digress for a moment to deal with it. In a letter commenting on Mr. Garvan's recent message to the American Chemical Society, General Gilchrist,[1] Chief of the Chemical Warfare Service, touches upon the subject briefly but adequately.

> Mr. Garvan does not infer that chemistry, in conjunction with the airplane, will insure the peace of the world by making war so horrible that nations cannot engage in it; but rather that the possessor of weapons based on these great scientific developments can make war so effectively as to make it impossible for weaker nations along these lines to engage in it.
>
> This is a proposition to which I have given much thought; and I am inclined to believe that the way to peace is not through making war horrible. In fact, I am inclined to think that any war of tomorrow will not be more horrible than those of the past. Wars of ancient days were infinitely more terrible than those of recent times, and yet wars have continued as instruments of national policy. Improvements in weapons have tended to reduce the percentage of deaths on the field of battle, and the laws of war have given increasing protection to non-combatants.

[1] The letter here cited was in reply to an inquiry from Senator Joseph E. Ransdell and was read into the Congressional Record of November 19, 1929.

History proves beyond a doubt that with the improvement in methods of warfare mortality and suffering have been lessened. In the World War we had poison gas, airplanes, machine guns, and various forms of high explosives which theoretically might exterminate any army, but a careful survey of the casualties shows that the loss of life proportionate to the number engaged was not nearly as large as in our own Civil War.

When man was less civilized war meant extermination or slavery for the vanquished, civilian as well as soldier. The wounded were ruthlessly slain, cities sacked and burned, crops destroyed, and women and children killed or enslaved. War could never be more horrible than in the early days of history, yet it persisted throughout the ages. Happily there is no reason to believe that if we ever again are forced into a national struggle we will ever return to the frightful carnage which resulted from hand-to-hand combat with battle-ax, spear, and dagger.

As a matter of fact, the chemical weapons developed in the last war and since can be shown conclusively to be the least inhumane. Some 30 per cent of the American casualties were due to gas, but of this number less than 2 per cent died. Of the 70 per cent casualties which resulted from the use of the older weapons of war some 24 per cent died, showing that the ratio in the American Army of deaths from gas and deaths from weapons other than gas is about 1 to 12. The British statistics bear out this comparison. For full explanation of this subject, and of the foolish statements that gas causes tuberculosis, blindness, etc., I am inclosing a study of the subject made by me, entitled "World War Casualties from Gas and Other Weapons."

From a military viewpoint there is nothing to be gained and much to be lost by seeking horrible weapons. War is a method of imposing the national will on an enemy. Wars are tremendously expensive; and if, as a result of them, the enemy is so weakened as to be unable to pay the bill, the winner loses along with the vanquished. Therefore the least destruction of material or personnel resources possible is the most desirable from all viewpoints.

In modern chemistry and aeronautics lie effective means for such warfare, although I do not believe that the airplane will drive armies from the field or navies from the ocean. That nation which leads in scientific developments, however, can make war so effectively by these means as to make it impossible to any nation less industrially and scientifically prepared. That, I think, is what Mr. Garvan had in mind when he prepared his letter for the American Chemical Society. In chemistry and the chemical industries we find a plowshare most easily, simply, and economically practicable for conversion into a sword.

Science, then, will not necessarily or probably make war more horrible or more destructive, but it will make war more expensive. The time when an impecunious seeker of fortune could initiate military operations on a shoestring with any hope of success is long past. Thus we may postulate that science is gradually bringing into operation a benign circle. Those who have will be more and more reluctant to make war; those who have not will find it futile to attack those who have.

As a concession to those who doubt that we are to see any speedy solution of this vexatious problem of the ages we refrain from setting the date when the much-to-be-desired equilibrium which we have indicated will be attained.

THE DIALYZER

1. Who is the only scientist to have twice received the Nobel award? (pp. 225–7, 268–76, 461–2.)

(*For questions* 2–5 *see* pp. 232–44.)

2. What well-known chemist is given credit for the discovery of aluminum?
3. Had any investigators before Hall's time attempted to obtain aluminum from cryolite?
4. Where are the original aluminum buttons made by Hall?
5. What comparatively recent demonstration of acknowledgment of Hall's contribution to science has occurred? Where?
6. Under what conditions is aluminum adaptable for structural work? (pp. 245–56.)

(*For questions* 7–8 *see* pp. 257–67.)

7. Who has been designated by Sir Wm. Osler as "the most perfect man who ever entered the Kingdom of Science?"
8. What is "Bios?" How related to fermentation?
9. Are you interested in the views of an eminent researcher on the education of our younger students? (pp. 283–93.)

(*For questions* 10–13 *see* pp. 294–312.)

10. What two types of chemical grenades are there? What is the essential make-up of each?
11. What was the first gas mask used by the Allies?
12. What are the essential features of the latest type of American gas mask?
13. What is the function of the sodium hydroxide in the gas mask absorbent commonly used?
14. Upon what factors does the tendency of a metal to corrode depend? The rate of corrosion reaction? (pp. 316–20.)
15. Are you looking for a popularized study course in chemistry? (pp. 325–40.)
16. How can titrations in non-aqueous solvents be used to present a more generalized viewpoint of conductance? (pp. 341–8.)
17. Are you looking for a device to help you get across to your beginning students the gas laws of Boyle and Charles? (pp. 355–7.)
18. Would a few new suggestions for laboratory projects be helpful? (pp. 358–60.)

(*For questions* 19–21 *see* pp. 371–88.)

19. How long has chemistry been included in the curricula of normal schools and teachers' colleges of this country? Of secondary schools?
20. When was individual laboratory work introduced into these schools?
21. What are the present-day tendencies in teaching chemistry in these schools?

(*For questions* 22–23 *see* pp. 399–402.)

22. How can synthetic rubies and sapphires be differentiated from the natural articles?
23. Why are these gems important to the electrical industry?

(*For questions* 24–26 *see* pp. 403–19.)

24. Besides the head on beer, and dough, what else has carbon dioxide been used to raise?
25. What is "carbogen?" Where is it used?
26. How is solid carbon dioxide used in the laboratory most effectively for cooling purposes? How can the temperature be controlled?
27. Should the ingredients of a photographic developer be mixed in any special order? Why? (pp. 420–33.)
28. What is "Dithizon?" To what analytical use may it be put? (p. 453.)
29. What is the newest development in electrolytic manufacture of hydrogen peroxide? (p. 455.)
30. Where is the world's only amber mine? (p. 457.)

CHARLES M. HALL AT FORTY-THREE
1863–1914

THE STORY OF ALUMINUM

HARRY N. HOLMES, OBERLIN COLLEGE, OBERLIN, OHIO

A century ago, in 1827, to be exact, the great Wöhler heard that Oersted, able Danish chemist, had separated aluminum from its chloride in 1825 by heating with potassium amalgam. Wöhler repeated the experiment with such poor success that he declared Oersted had never really secured the element. So dominating a figure in the chemical world was Wöhler that Oersted's discovery was discredited and soon forgotten. For nearly a century his paper was buried in some obscure Danish publication before the ardent patriotism of his countrymen brought it to the world's attention.

But Wöhler, skeptical as to Oersted's success, determined to win the element himself and win he did. It may be argued that he had the advantage of Oersted's ideas but it seems clear that Wöhler's method was an improvement on Oersted's procedure. Oersted probably made aluminum in 1825 but Wöhler obtained a better product by his reduction of anhydrous aluminum chloride with potassium.

$$AlCl_3 + 3K \longrightarrow 3KCl + Al$$

The scientific world first learned about aluminum as a metal from Wöhler's brilliant discovery and has always given him the credit.

Unfortunately the cost of the active metal potassium was such that the newly won aluminum had to sell at $160 a pound! It was proudly placed on museum shelves and there it remained until the Oberlin College student, young Charles M. Hall, made it useful, in 1886. But we are getting ahead of our story.

The eminent French chemist, Deville, lowered the cost in 1854, by the simple substitution of the cheaper metal sodium for potassium in attack on a mixture of aluminum chloride and sodium chloride.

$$AlCl_3 + 3Na \longrightarrow 3NaCl + Al$$

Within two years, by 1856, the price of the metal dropped from $90.00 per pound to $20.00.

Sir Humphry Davy made earlier attempts than Wöhler's to reduce the oxide and failed, as did Silliman. Berzelius, the eminent Swedish chemist, almost succeeded in anticipating the success of Wöhler when he heated cryolite, the double fluoride of aluminum and sodium, with potassium. Unfortunately, he used an excess of potassium and got an alloy of aluminum with potassium. Had he used an excess of cryolite, Berzelius would now be given credit for presenting aluminum to science. Deville actually gave them all a start on the right track in another method that failed. He electrolyzed melted cryolite, a double fluoride of aluminum and sodium, but the results were unsatisfactory. Bunsen is said to have done the same thing at the same time. Half a century later these unsuccessful experi-

ments were dragged into court in an effort to deny Charles M. Hall the fruits of his own great discovery.

Then came Castner who with admirable clearness saw that cheaper sodium meant cheaper aluminum. With equally admirable directness he proceeded to devise a cheaper process of making sodium and at once cut the cost of aluminum to the encouraging figure of $4.00 (some say $6.00) a pound. Then, just at the moment of reasonable success, poor Castner was flattened by the news of young Hall's great discovery! But Castner was no quitter. He went right on and won fame and fortune with his invention of the Castner electrolytic cell for the manufacture of sodium hydroxide, "caustic soda."

This brings us to a serious-minded, studious young lad, the son of a minister in the village of Oberlin, Ohio. There was good New England ancestry and real character in this family but in the Hall home there was no surplus money for anything beyond very plain living.

As a boy Charles M. Hall read widely, was very industrious, scarcely knew what play was. His own brother once said:

> Aside from his studies in school and his self-imposed tasks every moment was devoted to reading or studying along scientific lines, with occasional relaxation in music. His mind turned already to invention, and his college days were filled with dreams of discovery which should bless the world.

Hall's sister Julia wrote in 1915:

> During the years in high school and college, Charles was always thinking about and working to perfect what he called, with a smile, his "schemes." He gave time and thought to other matters beside the aluminum process. One invention in particular he worked out when he was about seventeen years of age. This was a valuable invention but Charles found that it had been already patented.

It was most fortunate for Hall and for Oberlin College that in 1880 Frank Fanning Jewett accepted the chair of chemistry and mineralogy, bringing to the work a training equal to the best of that time. A Yale graduate, he had gone to Germany where, in Göttingen University, he was one of the small group of American students who at that time specialized in chemical work under highly trained German teachers. Among his close friends at Göttingen were Provost Edgar F. Smith of the University of Pennsylvania, Professor Harmon Morse of Johns Hopkins and Professor Mears, Sr., of Williams College. After his return from Germany Professor Jewett served as research assistant to Wolcott Gibbs of Harvard and, later, for a period of four years as professor of chemistry at the Imperial University of Japan.

On the occasion of the 50th reunion of his Yale class (1920) Professor Jewett, like all his classmates, was asked to give an accounting for his 50 years of activity since leaving Yale. His remarks are worth presenting here as valuable historical material.

My great discovery has been the discovery of a man. When I went to Oberlin in 1880, on my return from four years' teaching in Japan, there was a little boy about fourteen years old who used to come to the chemical laboratory frequently to buy a few cents worth of glass tubing or test tubes or something of that sort and go off with them. He would come again after a while to get some more things to work with.

Not knowing anything about the boy I made up my mind that he would make a mark for himself some day because he didn't spend all his time playing but was already investigating. That boy was Charles M. Hall, the man who, at the age of twenty-one, discovered the method of reducing aluminum from its ores and making it the splendid metal that we now see used all over the world. Hall was an all-round student, but he did have a special liking for science.

After he had entered college and was part way through the regular course, I took him into my private laboratory and gave him a place by my side—discussing his problems with him from day to day.

Possibly a remark of mine in the laboratory one day led him to turn his especial attention to aluminum. Speaking to my students, I said that if any one should invent a process by which aluminum could be made on a commercial scale, not only would he be a benefactor to the world but would also be able to lay up for himself a great fortune. Turning to a classmate, Charles Hall said, "I'm going for that metal." And he went for it.

He tried various methods in vain, and finally turned his mind to the idea that perhaps electricity would help get the metal out of its ores. So he focused his attention on that process. I loaned him what apparatus I had to spare, what batteries we could develop. And I think that most of you who have seen an electric battery would have laughed at the one we got up—made as it was out of all sorts of cups, tumblers and so on, with pieces of carbon in them. But we finally got the current that was needed.

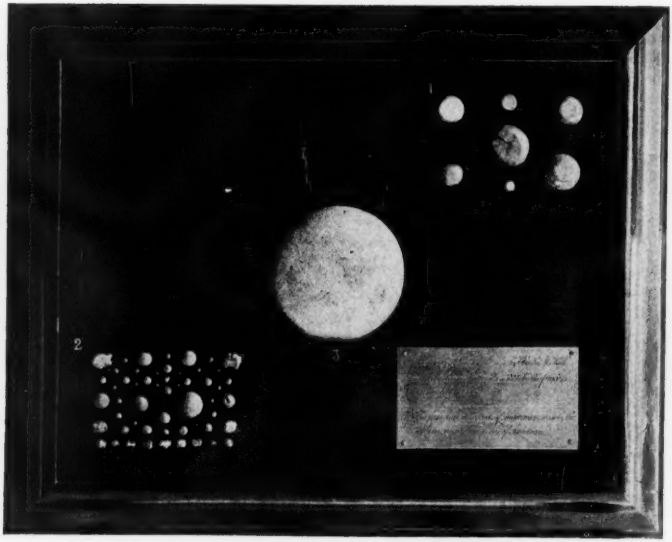
Soon after this he was graduated and took the apparatus to his own home; apparatus which he himself had made and which I had loaned to him. He arranged a little laboratory in the shed, continued his investigations and reported to me frequently.

About six months later he came over to my office one morning, and holding out his hollowed hand said: "Professor, I've got it!" There in the palm of his hand lay a dozen little globules of aluminum, the first ever made by the electrolytic process in this country. This was the 23rd of February, 1886. After that he developed his invention to its final great success.

Some further reminiscences of Professor Jewett's, written in 1914, are of great importance in throwing light on the relation of teacher to pupil and to discovery. It will be seen that Jewett inspired, advised, helped and encouraged his pupil Hall, taught him all the chemistry the boy knew and gave him the priceless privilege of a place in the master's private laboratory. Jewett did not make the discovery but he was necessary to it.

Even before he entered college, the subject of extraction of aluminum from its ores had occupied his mind. During his college course, even while engaged in regular chemical studies, he did some investigating on the subject.

At one time, he suggested that he and I should undertake to find a better material than carbon for the fiber in the incandescent lamp. He concluded that tungsten would answer. It was agreed that I should furnish the materials and that he should do the work in my private laboratory. Here he had his own desk, which he continued to use during his senior year. He worked with tungsten compounds for a season and finally found one which we thought might answer the purpose. When a fiber made of this



Courtesy of Fisher Scientific Co.

THE ALUMINUM "CROWN JEWELS"

In this frame, carefully preserved by the Aluminum Company of America at Pittsburgh are the original buttons of the metal made by Charles M. Hall in Oberlin, February 23, 1886 (lower left), the larger ones made by Hall in December, 1886 (upper right), and the first button or ingot (center) produced by the Alminum Company of America.

tungsten was subjected to as strong a current as the laboratory afforded it glowed brightly for an instant or two, then snapped asunder. It was planned to take up the subject later, but circumstances would not permit. (Had they stuck to tungsten the tungsten lamp might have arrived twenty years earlier.)

Mr. Hall first tried to extract aluminum from clay by fusing it in a crucible with carbon and chlorate of potash, but nothing came of it. Later he tried to get aluminum from its oxide by fusing with different substances. Toward the end of his college course he finally abandoned altogether the idea of securing aluminum by reduction, and turned his thoughts extensively to electricity as the form of energy to be employed in separating aluminum from its compounds.

In talking the matter over he asked me at one time regarding the compound which could be most readily decomposed by the electric current, knowing that in gold and silver plating the cyanides of those metals were used. I suggested such a compound for aluminum. We soon concluded, however, that this would be impracticable on a large scale, and we next considered the fluoride. Lead dishes were now supplied in which to make these substances, and he worked assiduously for many days in preparing them. When a satisfactory compound was finally made the next step was to prepare an electric battery that would furnish a current strong enough to decompose it. All the battery cells that the laboratory could supply were pressed into service. This battery was then enlarged by additional cells made out of beakers, tumblers, jars, and everything else

that ingenuity could devise, all to no purpose, however. The electric current was not strong enough to do the work.

Soon after this Mr. Hall was graduated from college, and in 1886 fitted up a laboratory in a shed at the rear of his father's house on East College Street. Thither he carried the apparatus loaned him from the laboratory, and continued his work, occasionally coming to speak of his progress, and to talk about the difficulties which arose at almost every step of his investigation. These difficulties, however, never quelled his enthusiasm nor disheartened him.

Hall's own story is most interesting and we are able to quote from his address on the occasion of the presentation of the Perkin Medal to him on January 20, 1911.[1] The young French chemist, Heroult, working independently had made the identical discovery only a month or two later than Hall, and at the same age, twenty-two years. It was graceful and generous of Heroult to cross the Atlantic in 1911 in order to congratulate Hall as the Perkin Medal was awarded.

My first knowledge of chemistry was gained as a school-boy at Oberlin, Ohio, from reading a book on chemistry which my father studied in college in the forties. I still have the book, published in 1841. It is minus the cover and the title-page, so I do not know the author. It may be interesting now to see what this book, published seventy years ago, says about aluminum: "The metal may be obtained by heating chloride of aluminum with potassium in a covered platinum or porcelain crucible and dissolving out the salt with water. As thus prepared it is a gray powder similar to platinum, but when rubbed in a mortar exhibits distinctly metallic lustre. It fuses at a higher temperature than cast-iron and in this state is a conductor of electricity but a non-conductor when cold."

Later I read about Deville's work in France, and found the statement that every clay bank was a mine of aluminum, and that the metal was as costly as silver. I soon began to think of processes for making aluminum cheaply. I remember my first experiment was to try to reduce aluminum from clay by means of carbon at a high temperature. I made a mixture of clay with carbon and ignited it in a mixture of charcoal with chlorate of potassium. It is needless to say that no aluminum was produced. I thought of cheapening the chloride of aluminum then used as the basis for aluminum manufacture, and tried to make it by heating chloride of calcium and chloride of magnesium with clay, following the analogy by which iron chloride is produced when common salt is thrown into a porcelain kiln. A little later I worked with pure alumina and tried to find some catalytic agent which would make it possible to reduce alumina with carbon at a high temperature. I tried mixtures of alumina and carbon with barium salts, with cryolite, and with carbonate of soda, hoping to get a double reaction by which the final result would be aluminum. I remember buying some metallic sodium and trying to reduce cryolite but obtained very poor results. I made some aluminum sulfide but found it very unpromising as a source of aluminum then, as it has been ever since.

On a later occasion I tried to electrolyze a solution of aluminum salt in water, but found nothing but a deposit of hydroxide on the negative electrode. I did not give a great deal of time to these experiments, as I was then a student in college and was working on three or four other attempted inventions.

I had studied something of thermo-chemistry, and gradually the idea formed itself in my mind that if I could get a solution of alumina in something which contained no

[1] See "The Perkin Medal Award," *J. Ind. Eng. Chem.*, **3**, 143–51 (Mar., 1911).

water, and in a solvent which was chemically more stable than the alumina, this would probably give a bath from which aluminum could be obtained by electrolysis.

In February, 1886, I began to experiment on this plan. The first thing in which I tried to dissolve alumina for electrolysis was fluorspar, but I found that its fusing point was too high. I next made some magnesium fluoride, but found this also to have a rather high fusing point. I then took some cryolite, and found that it melted easily and in the molten condition dissolved alumina in large proportions. I rigged up a little electric battery—mostly borrowed from my professor of chemistry, Professor Jewett, of Oberlin College, where I had graduated the previous summer. I melted some cryolite in a clay crucible and dissolved alumina in it and passed an electric current through the molten mass for about two hours. When I poured out the melted mass I found no aluminum. Then it occurred to me that the operation might be interfered with by impurities, principally silica, dissolved from the clay crucible. I next made a carbon crucible, enclosed it in a clay crucible, and repeated the experiment with better success. After passing the current for about two hours I poured out the material and found a number of small globules of aluminum. I was then quite sure that I had discovered the process that I was after.

I undertook to broaden and improve the method, and found that I could use, instead of cryolite, other double fluorides, particularly a double fluoride of potassium and aluminum. The most important change, however, which I made at this time, was in the material used as an anode. I wanted to get rid of the burning up of the carbon anodes. I tried a platinum anode and found that it seemed to work all right, but it was too expensive. I discovered that if I used a fusible bath of potassium double fluoride with a sodium double fluoride, I could use a copper anode, which immediately became coated with a thin film of copper oxide and acted like a permanent platinum anode. This was not a step in advance as I had hoped, because more or less copper got into the reduced aluminum, and the use of a copper anode led me to use very fusible baths, which on the whole did not work as well as the less fusible baths. It is probable that this change delayed a successful result for a year or two.

When worked on a small scale, this process with any of the baths I have mentioned, and with either copper or carbon anodes, is not apparently promising. The ampere efficiency is low, sometimes zero, and the bath, whether composed of sodium or potassium salt, becomes filled with a black substance which accumulates and renders the process very difficult. I presume that my friend, Dr. Heroult, whom I have the pleasure of seeing here tonight, who invented the process independently in France about the same time, encountered the same difficulties. In spite of the difficulties mentioned, however, I had great faith in the theoretical possibilities of the process, and believed that the practical obstacles could be overcome, so I stuck to it from the start.

In the summer and fall of 1886, I worked with some people in Boston with whom my brother had made some financial arrangement. The results there obtained were not satisfactory to them, and in October, 1886, my Boston friends declined to go further.

In December, 1886, I returned to my home in Oberlin, continued my study, and found that a bath composed of a very fusible double fluoride of aluminum and potassium, with copper anodes, worked much better than anything I had before tried.

The Cowles Electric Smelting and Aluminum Company, who were then making aluminum alloys at Lockport, New York, were the second set of people who became interested in my invention. They took an option on it, and I spent a year with them, from July, 1887, to July, 1888. They finally gave up their option. The baths which I used at Lockport worked well for a few days, but after a time became less efficient. I finally worked out a system by which the difficulties were overcome. This was by making a bath consisting partly of calcium fluoride, or fluorspar, and adding three or four

THE CHARLES M. HALL HOUSE ON EAST COLLEGE STREET, OBERLIN
The woodshed in which Hall's discovery was made was recently—and unfortunately—removed, but this photograph, at least, preserves it.

per cent of calcium chloride, and using carbon anodes. I reasoned that chlorine was evolved and burned up the objectionable compound which spoiled the bath. After finally overcoming the difficulties which I have mentioned, I made several pounds of aluminum in small crucibles, which I showed to Mr. Alfred Cowles and gave him all the facts in relation to the same, but he was not interested.

I then sent a representative, Mr. Romaine Cole, now dead, to Pittsburgh, to get together the gentlemen who formed the Pittsburgh Reduction Company, now the Aluminum Company of America. We started in the summer of 1888 to build and operate a commercial plant on Smallman Street in Pittsburgh. We had at our disposal about fifty horse-power in electrical current of two thousand amperes. It took a few weeks after starting to get the dimensions of our baths just right, and then the difficulties which I have referred to disappeared as if by magic. The clogging and spoiling of the bath, which had caused trouble for the past three years, did not occur on a large scale. No calcium chloride was required. We also found, as I had predicted nearly three years before, that on a commercial scale no external heat was required to keep our baths in fusion. This was a great advantage, but I believe that it resulted from a law of nature and not from any invention, as we did not use any excess of current for maintaining fusion, but only the normal current and voltage for electrolytic purposes. The use of the electric current for fusing and heating in connection with electrolysis was a thing which had been disclosed and published almost a century before.

Hall's commercial success brought infringement suits by the Cowles Electric Smelting and Refining Company of Lockport, N. Y., in 1893. It is to be noted that Hall never entered their employ until *after* his discovery and also that he gave the Cowles Company an option on his process which they finally rejected. The Cowles people reduced aluminum oxide with carbon in the electric furnace but were forced to use copper to capture the aluminum. This was purely a high temperature reaction, not electrolytic, and produced only a copper-aluminum alloy. The temperature of reduction of aluminum oxide is close to the boiling point of the metal.

Judge Taft, later President Taft, decided in favor of Hall, in the U. S. Circuit Court of Northern Ohio. It was necessary in the trial that the date of Hall's discovery be set before the summer of 1886 and this Professor Jewett was able to do because he remembered clearly that he stood in his private laboratory in the north wing of old Cabinet Hall when the young discoverer rushed in with a few shining buttons in his hand and said "I've got it!" This north wing of Cabinet Hall was torn down in the summer of 1886 to make room for the south wing of the new Peters Hall.

Judge Taft said:

> Hall's process is a new discovery. It is a decided step forward in the art of making aluminum. Since it has been put into practical use the price of aluminum has been reduced from $6.00 or $8.00 a pound to 65 cents. This is a revolution in the art, and has had the effect of extending the uses of aluminum in many directions, not possible when its price was high. . . .Hall was a pioneer, and is entitled to the advantages which that fact gives him in the patent law.

This important decision did not end the fight for in 1900 the Cowles Company, which in the meantime had bought the Bradley patents, sued

BRONZE TABLET PLACED ON THE HALL HOME IN OBERLIN, OCTOBER 30, 1928

again in the U. S. Circuit Court of Western N. Y. and lost once more. They appealed and won damages in 1903 but the court ruled that since Bradley had merely electrolyzed an aluminum ore he could not in turn infringe on Hall who electrolyzed aluminum oxide dissolved in a fused aluminum ore. Litigation ended there.

For those interested in exact details it may be stated that Hall applied for patents July 11, 1886, and was granted his basic patent, No. 400,766, as well as three or four others on April 2, 1889.[2]

Mr. Arthur V. Davis, an associate of Hall's from those first days in Pittsburgh and later president of the Aluminum Company of America, insisted that Hall's inventive work after his original discovery was just as important and brilliant as the first success. Mr. Davis notes two preëminent qualities in Mr. Hall's work—persistence and versatility.

> There were many vicissitudes and many dark days, but in the darkness of those days Mr. Hall never seemed to share. He always had an abiding faith that his process

[2] In this connection some interesting material concerning the Hall patents will be found in the following articles: "Chemical Patents," S. C. Mesick, *J. Ind. Eng. Chem.*, **7**, 789–97, 874–82, 984–91, 1071–81 (1915); "Studies in Chemical Patent Procedure. I. Hall Patents for Aluminum Production," L. Van Doren, *Ind. Eng. Chem.*, **21**, 120–4 (Feb., 1929).

was right and that the company was good, and that the aluminum industry had a future. From this fundamental belief, Mr. Hall's faith and courage never wavered.

Hall was a good business man and held on to one-fourth the stock in the powerful Aluminum Company of America, the Mellon bankers of Pittsburgh holding about one-half. On his death in 1914 Hall left one-third of his estate to Berea College, Kentucky, one-third to education in the Orient, and one-third to Oberlin College. This has finally come to mean from $12,000,000 to $15,000,000, the larger part of Oberlin's endowment.

So this dreamer, musician, connoisseur in art, chemist, inventor, and shrewd business man, actually refounded his alma mater.

It was most appropriate that on October 30, 1928, a bronze memorial tablet in honor of Hall's discovery and his very great services to the world was placed on the old Hall home at 64 East College St., corner of Pleasant, in Oberlin. The woodshed in which the discovery was brought to triumphant conclusion was torn off recently but the house remains. (This was not the first woodshed that was closely associated with the early development of great Americans.) Distinguished scientists, high officials of the Aluminum Company of America and Dr. Dan Bradley of Cleveland, whose ribs were nudged by young Hall's elbow that day in class when, inspired by Professor Jewett's remarks on aluminum, Hall whispered, "I'll be that man"—all these, with surviving classmates, the faculty, and 1800 students were there to do honor to Hall.[3]

And it was a graceful gesture by Richard B. Mellon that sent to Severance Chemical Laboratory of Oberlin the life-size aluminum statue (alloyed with silicon to dull it artistically) of the dreamer, planning his great invention. This striking statue is the work of G. Moretti of Pittsburgh. The largest of the historic buttons of metal made by Hall in his woodshed, February 23, 1886, was also given to Severance Laboratory where it is a part of the most unusual and complete aluminum exhibit in this country.

The growth of the aluminum industry has been marvelous. The world now makes nearly 500,000,000 pounds annually and of this more than 160,000,000 pounds are made in the United States. The Aluminum Company of America is transferring much of its production to Canada and some to Norway. Formerly it depended upon Arkansas bauxite, an impure oxide of aluminum, and upon Greenland cryolite for its raw materials. Now the company draws also upon the bauxite of British and Dutch Guiana, the purest in the world. Far above the city of Quebec, on the Saguenay River, this company is developing one million horsepower electrically and there will be the aluminum center of America, at the new town of Arvida.

Aluminum cooking utensils, cables for electric power transmission (200,000 miles in use), and alloys such as the golden bronzes (90 per cent

[3] See "The Second Century of Aluminum," *News Edition, Ind. Eng. Chem.*, 6, 1 (Nov. 10, 1928).

Courtesy of Fisher Scientific Co.

LIFE-SIZE ALUMINUM STATUE OF CHARLES M. HALL

This statue was executed by G. Moretti and presented to Severance Chemical Laboratory by Mr. Richard B. Mellon. It was formerly loaned to the Carnegie Museum.

SEVERANCE CHEMICAL LABORATORY, OBERLIN COLLEGE

copper and 10 per cent aluminum) have made the metal famous. Now comes "duralumin," the light and strong alloy used in making the framework of Zeppelins, successful plating of nickel and chromium on aluminum, light aluminum furniture that looks like wood, and the marvelously pure "alclad" sheet which is rolled on the strong duralumin to give it better resistance to corrosion.

The story of Charles M. Hall,[4] like the classics, will be told many times but it will never lose its appeal to the imagination.

[4] For an obituary note see "Charles M. Hall," by C. F. Chandler, *J. Ind. Eng. Chem.*, **7**, 155–7 (Feb., 1915).

Germs Measure Strength of New Disinfectants. Making germs step up and get killed by new disinfectants and antiseptics, to get an idea of the strength the latter substances will have when used in active service, is one of the tricks of the trade in modern bacteriology. One of the most evil of germs, the *gonococcus*, cause of one of the so-called social diseases, is employed in this way by Herbert C. Hamilton of Detroit. At the fall meeting of the American Chemical Society at Minneapolis he described his technic for using this dangerous organism in standardizing germicidal chemicals.—*Science Service*

SOME COMMERCIAL APPLICATIONS OF ALUMINUM

DOUGLAS B. HOBBS, ALUMINUM COMPANY OF AMERICA, PITTSBURGH, PENNSYLVANIA

If "tin hats" had been worn by the soldiers during the War between the States, they would not have been of aluminum. There were, at that time, aluminum helmets, but helmets were worn only by royalty, and only royalty could have afforded aluminum helmets. Had tea pots and coffee urns been fabricated from this light metal when Napoleon III was wearing a helmet cast from it, they would have been placed in the parlor on the mantle, or hidden in the chimney with the most cherished possessions of the household at the time of Sherman's march to the sea, for aluminum was truly a precious metal.

But aluminum was not always to remain a precious metal. From a price of $17 an ounce in 1854 to approximately 20 cents a pound in less than half a century is industrial progress not to be overlooked. Important as price reduction may be, there was no appreciable market for aluminum even after Hall had succeeded in developing a satisfactory means for producing it cheaply. The mention of $2 a pound in 1000-pound lots as early as 1890 did not apparently interest any one. No one wanted a thousand pounds of aluminum. This meant that markets had to be created.

Aluminum began to compete with gravity, with corrosion, with thermal and electrical conductivity, as well as with workability. In this struggle, seldom was the choice of any metal based on one property alone; the metal had to possess a combination of properties. For example, there was need for lightness and strength in one instance, and in another instance, for not only lightness and strength but resistance to corrosion as well. Such a condition as this meant that new alloys must be developed, each of which had its own field of usefulness. Had it not been for this development aluminum undoubtedly would have served only for pots and pans, and for chemical and electrical equipment in which the chemical and electrical properties of the pure metal were essential. Aluminum could not have served as a material of construction.

With the advent of strong aluminum alloys, light weight could be realized in structural parts without sacrificing strength or safety, since these alloys in the wrought form have the strength of mild steel and, at the same time, retain the well-known characteristics of the parent metal. Briefly summarized, these include low specific gravity, good resistance to corrosion, high thermal and electrical conductivities, and pleasing appearance.

The physical properties of the strong aluminum alloys are shown in Table I. The maximum properties are obtained only after the cast structure has been completely obliterated and the alloys have been fully heat-treated and aged. There are, however, other tempers besides the fully heat-treated and aged temper: these are the annealed and the heat-treated tempers. The various tempers are designated by letters added to the

TABLE I

PHYSICAL PROPERTIES OF STRONG ALUMINUM ALLOYS

ALLOY	TENSILE STRENGTH (Lb. per sq. in.)	YIELD POINT (Lb. per sq. in.)	ELONGATION (% in 2 in.)	BRINELL HARDNESS (500 kg. load) (10 mm. ball)
51SO	14,000–19,000	4,000– 6,000	22–32	25–32
51SW	30,000–40,000	15,000–20,000	20–30	55–70
51ST	45,000–50,000	30,000–40,000	10–18	90–100
25SO	23,000–35,000	7,000–12,000	12–20	45–55
25SW	45,000–53,000	15,000–30,000	15–22	68–85
25ST	55,000–63,000	30,000–40,000	16–25	90–105
17SO	25,000–35,000	7,000–10,000	14–22	45–55
17ST	55,000–63,000	30,000–40,000	18–25	90–105
B17SO	20,000–25,000		20–28	30–40
B17ST	42,000–50,000	20,000–25,000	20–28	65–85
A17SO	20,000–25,000		20–28	30–40
A17ST	35,000–45,000	15,000–20,000	20–28	55–75
C17SO	25,000–35,000	7,000–10,000	12–20	42–55
C17SW	55,000–63,000	30,000–40,000	18–25	90–105
C17ST	63,000–70,000	50,000–55,000	8–14	95–12

NOTES: The letters at the end of the alloy numbers designate the heat treatment: "O" standing for the annealed condition; "W" for the heat-treated condition; and "T," for the heat-treated and aged condition.

The Aluminum Company of America owns patents relating to No. 25S and No. 51S alloys and the heat treatment processes used in connection therewith.

alloy number: "O" standing for dead-soft or annealed; "W" for heat-treated; and "T" for heat-treated and aged. For example, 25ST is No. 25S alloy in the heat-treated and aged condition. No. 17S, No. A17S, and No. B17S alloys are not obtainable in the "W" temper, because after being heat-treated, they age spontaneously at room temperature. Cold forming may, however, be done immediately after quenching and before the alloys assume their fully aged temper.

TABLE II

PHYSICAL PROPERTIES OF NO. 2S AND NO. 3S ALLOY SHEET

TEMPER	TENSILE STRENGTH (Lb. per sq. in.)		ELONGATION (% in 2 in.)	
	No. 2S	No. 3S	No. 2S	No. 3S
Soft	12,000–16,000	15,000–18,000	30–45	15–30
1/4 Hard	14,000–18,000	18,000–22,000	5–10	5–8
1/2 Hard	16,000–20,000	20,000–24,000	3–7	2–6
3/4 Hard	19,000–23,000	24,000–29,999	1–4	1–4
Hard	22,000 (minimum)	27,000 (minimum)	1–4	1–4

NOTE: Elongations obtained on sheet in Brown and Sharpe gages 10 to 28 using the test specimen adopted by the American Society for Testing Materials; in the intermediate tempers, the specimen is taken parallel to the direction of rolling. Using standard 1/2-inch test specimens, these elongation values would be very substantially increased.

Where maximum strength is not a requisite for the wrought alloys, either commercially pure aluminum, No. 2S, or an aluminum-manganese alloy, No. 3S, may be employed. In the strong aluminum alloys, the tempers depend upon the heat treatment; while in No. 2S and No. 3S alloys, the tempers depend upon the amount of cold working. They are regularly produced in the annealed condition, in the hard temper, and in three intermediate tempers, designated as one-quarter hard, half hard, and three-quarters hard. The physical properties of No. 2S and 3S alloys are shown in Table II.

The physical properties of some of the more common casting alloys are indicated in Table III. These are obtained from the alloys in the "as cast" condition with the exception of No. 195 alloy. This alloy is furnished either in the heat-treated condition, the heat-treated and partially aged condition, or the heat-treated and fully aged condition, the suffixes "4," "16," and "10" being used to designate the heat treatment.

TABLE III

PHYSICAL PROPERTIES OF ALUMINUM CASTING ALLOYS

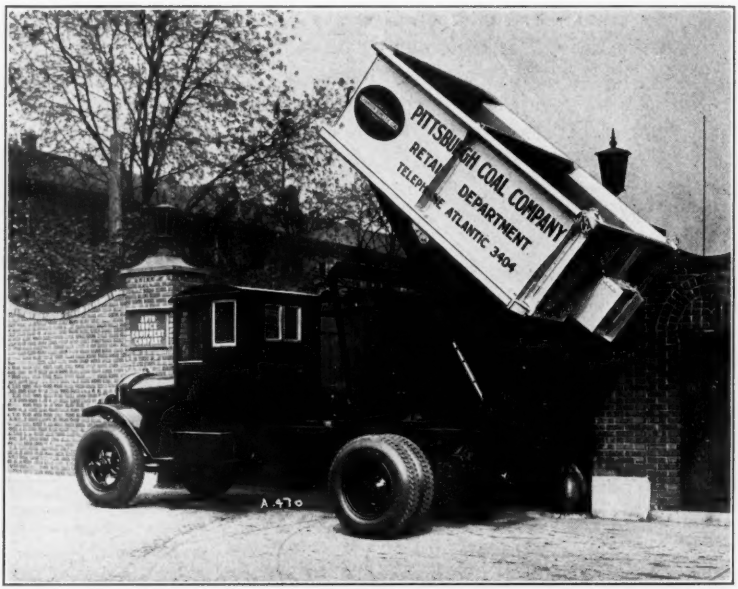
ALLOYS	TENSILE STRENGTH (Lb. per sq. in.)	APPROXIMATE YIELD POINT (Lb. per sq. in.)	ELONGATION (% in 2 in.)	BRINELL HARDNESS
12 (S. A. E. No. 30)	18,000–23,000	10,000	1.0– 3.0	65
112 (S. A. E. No. 33)	19,000–24,000	11,000	1.0– 2.5	65
122–10 (S. A. E. No. 34)	35,000–40,000	20,000	0.0– 1.0	115
109 (S. A. E. No. 32)	20,000–28,000	15,000	0.0– 1.5	80
195–4	28,000–38,000	13,500	6.0–12.0	65
195–16	30,000–40,000	21,000	3.0– 8.0	75
195–10	36,000–50,000	27,000	0.0– 5.0	100
43 (S. A. E. No. 35)	17,000–22,000	7,000	3.0– 7.0	40
145 (S. A. E. No. 31)	25,000–37,000	12,000	3.0– 6.0	65

NOTES: The numerical suffixes "4," "16," and "10" designate the heat treatment: "4" standing for the heat-treated condition; "16" for the heat-treated and partially aged condition; and "10" for the heat-treated and fully aged condition.

The Aluminum Company of America owns patents relating to No. 122, No. 195, and No. 145 alloys and the heat treatment processes used in connection with the first two.

In order to have a clearer conception of the industrial significance of these alloys, the application of aluminum in a few of the outstanding industries is mentioned by way of illustration.

In no other field, perhaps, is the need for light weight as important as in the transportation industry. As early as 1904, the automobile manufacturer recognized in aluminum a material of construction which would effect the desired weight reduction. Both wrought and cast aluminum alloys have been extensively used for such parts as the pistons, connecting rods, crank cases, oil pans, gear covers, windshield brackets, cowls and bodies, and for many years the aluminum casting industry has centered around the automobile.

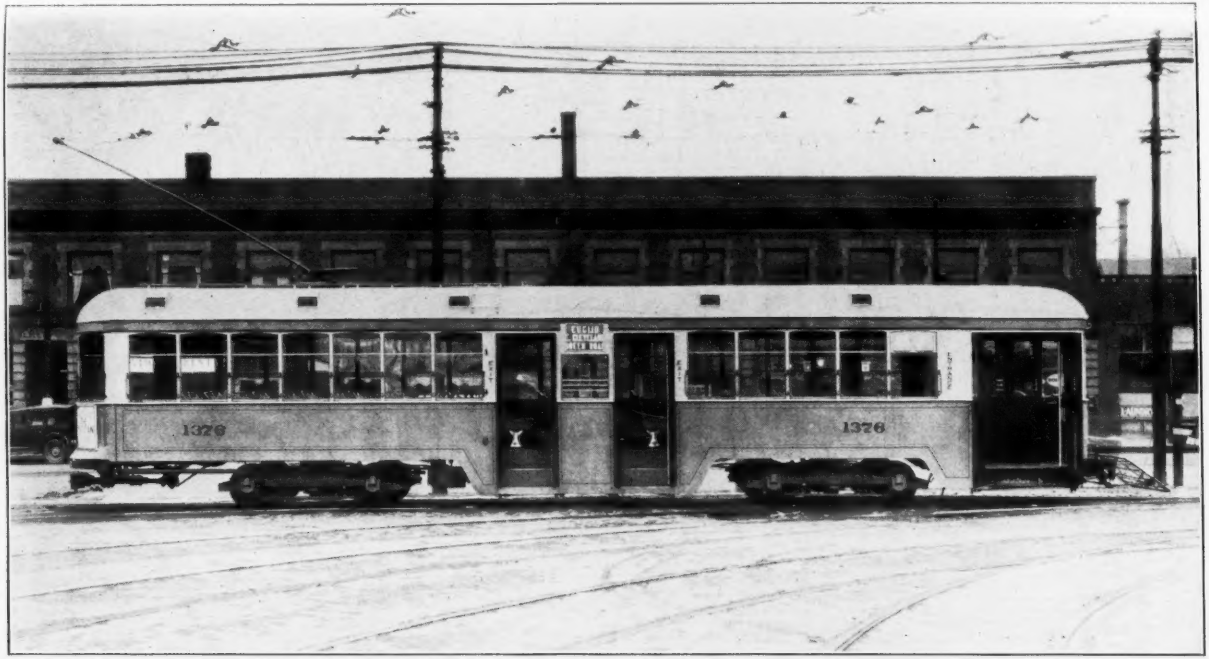


ALUMINUM ALLOYS AS A STRUCTURAL MATERIAL FOR TRUCK BODIES

The Pittsburgh Coal Company was able to increase the capacity of its heavy duty retail delivery trucks 18% by employing strong aluminum alloys in the hoists and bodies.

As a structural material for truck bodies aluminum alloys are interesting to builder and user alike. The gross weight of the trucks which may be operated on the highways of the several states is limited by legislation. The maximum allowable pay load, therefore, depends upon the tare weight of the chassis and body as well as upon the capabilities of the chassis. If heavy materials are used in body construction, the operator has no means of overcoming the handicap of weight limitation. But the use of aluminum alloys will materially decrease the weight of the body and increase the weight of the pay load. The advantage of weight reduction is not only realized in increasing the pay load but also while the truck is traveling light or with the same pay load it is capable of carrying with a heavier body. In the latter cases, improved schedules may be maintained due to the quicker acceleration and higher speeds which are possible. The fuel consumption and wear and tear on the chassis will also be lessened.

A survey of five different companies operating trucks with aluminum bodies showed that an average aluminum body cost approximately $600 more than a steel body, but yielded an increased revenue of $800 per year



THE CLEVELAND RAILWAY COMPANY'S ALUMINUM CAR

The trucks, body, hardware, and accessories were fabricated from aluminum. By employing aluminum wherever the metal was an engineering possibility, the weight per seated passenger was reduced from 900 pounds to 550 pounds. The car has been in continuous service since 1926.

of service. This meant that the higher initial cost of the aluminum body was written off within nine months, and after that time paid a return of $66 per month until its term of service was over. After the truck had reached this period, the residual aluminum in the body was worth approximately $300.

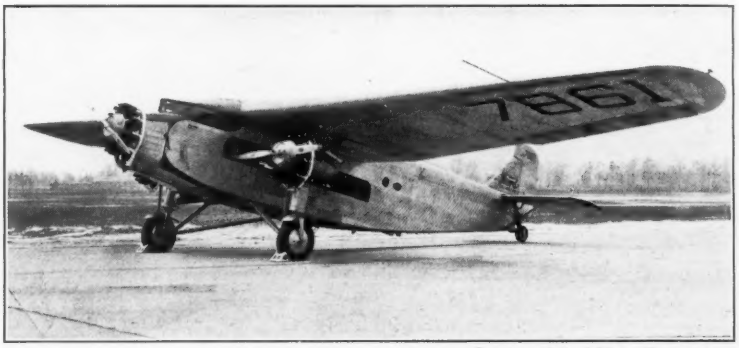
In order to cope with the ever-increasing automotive competition, it became evident as early as 1921 that radical changes would have to be made in street-car design and construction. The bus offered the riding public faster schedules and more comfortable equipment, and began to make a serious inroad into the business of street railway companies. In order to compete with not only the bus but the private automobile as well, it was necessary for the street railways to employ more luxuriously fitted cars and to operate them at higher schedule speeds. Light weight was recognized as a necessity in order to accomplish economically the speed characteristics. The Cleveland Railway Company, the Chicago and Joliet Railway Company, and the Springfield Street Railway Company were pioneers in this movement. They did not allow their engineering judgment to be hampered by the conventions of electric railway car building and the changes they made were by no means piece-meal. Aluminum was used wherever the metal was an engineering possibility. The efforts of these pioneers in aluminum car construction were far-reaching. Their experiments were so complete that today there are but few innovations in the use of aluminum; the expansion has been more commercial than experimental.

The initial cost of an aluminum car is, of course, higher than the cost of a car built from steel, but there is a material saving in propulsion energy. The cost of hauling dead weight has been figured by various operating authorities, and varies between 5 and 10 cents per pound per year on street railways to 3.5 cents per pound per year on heavy electric traction lines. Experience has shown that the additional cost of aluminum can be reduced to a unit figure of 20 cents per pound of weight saved. Only simple mathematics is necessary to figure how long it will take an operating company to gain returns on the additional cost of aluminum on this basis alone. This does not take into consideration any changes in power equipment. Where the schedule speeds being maintained with the heavier cars are sufficient, it is often possible to use a smaller, lighter, and less expensive motor.

The metal-clad dirigible recently built for the Navy by the Aircraft Development Corporation is one of the outstanding developments in aeronautics last year. It not only has an aluminum frame work, but the aluminum frame work is enclosed in aluminum sheet rather than in fabric. The aluminum sheet employed in covering the frame work is known under the trade name "Alclad." This consists of a core of strong alloy sheet covered on both sides by a thin film of pure aluminum which is an integral

Courtesy of Aircraft Development Corporation

NAVY'S METAL-CLAD DIRIGIBLE



Courtesy of Ford Motor Company

FORD'S TRI-MOTOR ALUMINUM PLANE

part of the core. The sheet combines the mechanical properties of the strong aluminum alloys with the excellent corrosion-resisting qualities of the pure metal. "Alclad" is used principally in the aircraft industry for the fabrication of sea planes and land planes which are subject to the corrosive action of moisture of one sort and another.

In the airplane, aluminum sheet and tubing are commonly employed in the construction of the wings and fuselage. Aluminum forgings and castings are used to some extent for brackets and braces, aileron levers, step plates, instrument plates, control levers, shock absorbers, brake drums and brake levers, but to a much greater extent in the motor. A few years ago, a forged aluminum crank-case would have been considered an engineering impossibility. Today one of the best-known radial motors has not only a forged crank-case but a forged nose piece as well. Forged aluminum propellers are standard equipment on most of the finer ships.

The outboard marine motor was made possible by the use of light aluminum alloys which would not corrode in contact with salt water. But aluminum has a much broader application in the ship-building industry than in outboard motors alone. In this connection, it might be mentioned that one of the largest castings ever produced in aluminum was the motor base plate for a Diesel engine. This casting weighed 3800 pounds.

The washing machine industry in the United States used over 21,000,000 pounds of aluminum during the year 1928, but this cannot be compared with the enormous amount used in the various fields of transportation. Due to the lightness of the metal and the ease with which it can be polished and finished, aluminum is extensively used in vacuum cleaners, washing machines, and other household appliances. Aluminum also finds its way into the home in the form of seals for glass-packed foods, beverages, lotions, cleaning fluids, and pharmaceutical products.

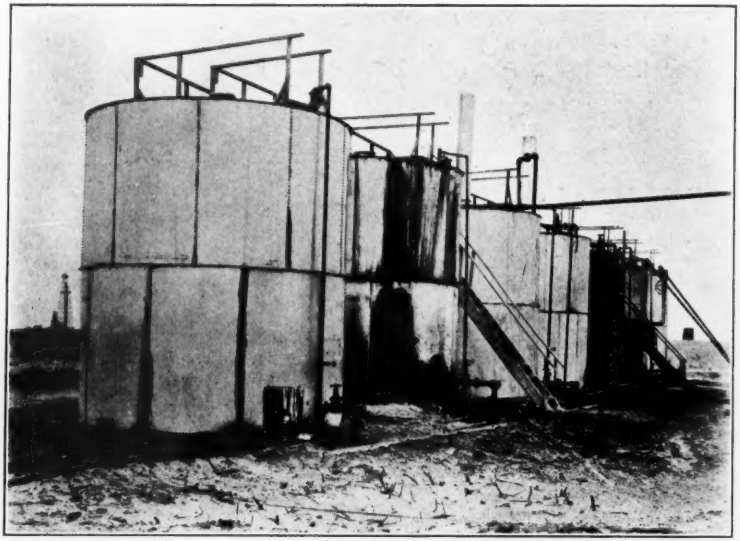
ALUMINUM FURNITURE

Directors' Room of the Johnson Motor Company, Waukegan, Illinois, showing a typical installation of aluminum chairs.

While aluminum furniture is used to some extent in the home, it is much more generally used in the office, airplane, dining car, and hotel. Colonel Lindbergh's flying office, for example, is equipped with aluminum furniture, and the chairs in the diners on many of the larger railroads are of aluminum. Since aluminum chairs are made of the strong aluminum alloys, they combine the strength of mild steel with the lightness of aluminum; they are fireproof. The chairs are of welded construction which eliminates the loosening of joints often caused by vibration or heat and moisture.

Because of the resistance of aluminum to hydrogen sulfide, aluminum equipment is employed to a large extent in the oil fields of West Texas and the Panhandle. Aluminum cable is used not only for the transmission of power but also for the swing-lines inside of storage tanks. The application of aluminum paint to oil tanks is well known. Steel tanks, thus painted, do not corrode as fast and the evaporation losses are materially reduced. In the days of wooden airplane propellers, aluminum foil was employed as a protective covering. Today it is applied with a suitable cement or varnish vehicle to the exposed surfaces of oil tanks and tank roofs, pipe lines, and house roofs to preserve the steel or wood. Aluminum bubble caps are used in some refineries.

Two experimental lease tanks of 500-barrel capacity have been in constant use since March 20, 1928, on the State-Lassiter lease of the Gulf Production Company, Crane County, Texas, without developing any leaks.



BATTERY OF 500-BARREL OIL TANKS

These tanks are on the State-Lassiter lease of the Gulf Production Company, Crane County, Texas. The tank at the extreme left is of aluminum construction throughout while the tank at the extreme right is of aluminum and steel. Both tanks have been in successful operation since March 20, 1928.

One of these tanks is of aluminum construction throughout, while the other tank is a composite aluminum-steel tank with the top ring and deck of aluminum and the lower ring and deck of steel. Adjacent tanks in other commercial metals developed leaks from corrosion within six months after their installation.

As in the oil fields and refineries, aluminum is extensively used in the rubber industry because of its resistance to the corrosive action of sulfur and sulfur compounds. Furthermore, rubber does not adhere readily to aluminum and it is easy to clean and polish the aluminum parts of a mold or inner tube mandrel after the rubber has been stripped off.

In the building field, aluminum roofing sheets and shingles, nails, corrugated sheet, and sheet metal fittings are in common use. Over 100,000 pounds of cast aluminum spandrels were employed on the Koppers Building, Pittsburgh. The sixty-eight story Chrysler Building in New York will have not only aluminum spandrels and copings but also aluminum ornaments at the various inset levels. The window sills throughout the building will be fabricated from this light metal. It is only natural that aluminum should be employed for architectural purposes because it is resistant

KOPPERS BUILDING, PITTSBURGH

Over 900 aluminum spandrels were used on this modern office building. Graham, Anderson, Probst, and White were the architects.

to atmospheric corrosion and does not form colored salts which will mar or stain the adjacent stone work. The lightness of aluminum is also an important factor, especially in bridge construction and in the construction of tall buildings.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for JUNIOR PATENT EXAMINER. Applications must be on file with the Civil-Service Commission at Washington, D. C., not later than February 18, 1930. The examination is to fill vacancies in the Patent Office, Washington, D. C. The entrance salary is $2000 a year. Higher salaried positions are filled through promotion.

The duties are to perform elementary scientific or technical work in the examination of applications for patents; to see what the alleged inventor thinks he has produced that is new; to see that the disclosure is complete; and to investigate the prior art as represented by patents already granted in the United States and various foreign countries and by the descriptions in technical literature.

Competitors will be rated on physics, technics, mechanical drawings, and the optional subject or subjects chosen. The optionals are (1) mechanical engineering, (2) physical and organic chemistry, (3) chemical engineering, (4) civil engineering, (5) electrical engineering. French or German, or both, may also be included if desired. Qualifying in the language test increases the probability of appointment.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or from the secretary of the United States Civil-Service Board of Examiners at the post office or customhouse in any city.

Nobel Chemistry Prize for Studies on Sugar. Studies of yeasts, sugars, and the fermentation of sugars, carried on over many years, won the 1929 Nobel Prize in chemistry for Dr. Arthur Harden and Prof. Hans von Euler.

Dr. Harden, professor of biochemistry in London University and head of the biochemistry department at the Lister Institute, has published a book on alcoholic fermentation, besides reports of his many chemical studies, some of which were in the field of vitamins.

Professor von Euler is director of the new biochemical institute of the Stockholm High School, which is really a university, where he has been professor of chemistry for some years. Like Dr. Harden, Professor von Euler has made studies of vitamins also, although his main interest has been in the field of enzymes and sugars. He has published two books on the chemistry of enzymes, besides hundreds of reports of studies conducted alone and in collaboration with others.

The studies of Dr. Harden and Professor von Euler are known to chemists in this country, but they have not heretofore attracted wide attention.—*Science Service*

Rustproof Steel Welds Easily. Rustproof steel is easily welded by the acetylene-oxygen process and is even more rustproof after welding than before due to loss of carbon, silicon, and manganese during melting. These findings by W. Hoffman, German metallurgist, have just been announced by the National Advisory Committee for Aeronautics here. The physical characteristics of rustproof-steel welds are better than those of soft-steel welds but the hardness of the metal due to welding must be removed by heat treatment. The rustproof steels most used contain large percentages of chromium or chromium and nickel.—*Science Service*

BIOS

W. Lash Miller, Professor of Physical Chemistry in the University of Toronto, Toronto, Canada

Readers of This Journal who have not yet read Vallery-Radot's "Life of Pasteur"[1] should deny themselves no longer. In that fascinating book we are told how Pasteur's endeavor to help the alcohol manufacturers of Lille diverted his interest from the study of crystals to that of fermentation; how in the course of a protracted controversy with believers in spontaneous generation he discovered in microörganisms the cause of diseases of wines and beer, and in "pasteurization" their cure; how he saved the silk industry of France from total extinction by discovering the bacterial origin of diseases exterminating the silkworms; and how by his study of anthrax, septicemia, chicken cholera, swine fever, gangrene, puerperal fever, and hydrophobia "he raised the veil which for centuries had covered infectious diseases by discovering and demonstrating their microbial nature" and rendered to mankind services impossible to exaggerate.

Pasteur was a fighter, "*per vias rectas*" his motto—"I shall force them to see;" after a heated meeting of the Philomathic Society, Duclaux suggested that he might as well have thrown the lecture specimens at his adversaries' heads, and as late as 1880 his way of discussing vaccine at the Academy of Medicine resulted in a challenge to a duel. Pasteur in short was human—Sir William Osler thought him "the most perfect man who ever entered the Kingdom of Science"—and we must not forget that his sharp replies were richly earned by passionate attacks often unjustified by the least attempt at experiment, or by the frivolous opposition of pompous emptyheads. His doctrine of germs revolutionized medicine, and the vanquished did not readily forgive; the world to which he pointed (and in which we all now live) seemed too fantastic, his promises too good to be true; "*taceat chimicus in medicina*" was the cry of some; "if this man be right, all we doctors need to do is set our nets to catch the spores of tuberculosis, and find a vaccine." His disproval of spontaneous generation was seized upon by clerical disputants as an argument for the conversion of unbelievers; and so some ardent spirits, dissatisfied with the Church's efforts to spread the light of science, felt impelled to take the other side: "M. Pasteur preached at the Sorbonne amidst a concert of applause that must have gratified the angels," wrote Edmond About, and as he wrote forgot that in this very matter the angels had been able to rely on the support of Voltaire himself.

These bygone controversies are recalled, not to revive them, but to illustrate the spirit of those days; time is required to quiet feelings so aroused, and even years after Pasteur's death criticism of his work was not always met objectively, as we shall see.

[1] René Vallery-Radot, "Life of Pasteur," with an introduction by Sir William Osler, New York, 1920, Doubleday, Doran and Co.; xxi + 484 pp.

The scientific question with which we are concerned arose during the celebrated dispute between Liebig and Pasteur as to the nature of fermentation; in Radot's "Life" this is represented as a clash between two discordant theories, in which that supported by Pasteur came out victorious; but the authors' own writings show that each was ready to concede the other's claim and only wished to stress the importance of his own. In Liebig's last paper on fermentation,[2] he acknowledged yeast to be a fungus and agreed there was no well-established case of alcoholic fermentation without the help of yeast; his own point was that to name a fungus when asked the reason for a fermentation was no reply, because the fungus acted only through some catalytic agent present in its body like the emulsin in bitter almonds or the invertase which Liebig himself was the first to prepare from yeast. To this contention Pasteur made no reply—why should he? Recognition that specific microbes are the originators of the various fermentations was all that he insisted on; how these microbes did their work was quite another matter. In point of fact there was, and is, no conflict between the "chemical" and the "microbial" theories of fermentation; and while we owe to Pasteur's work the establishment of bacteriological laboratories throughout the world, the chief endeavor of many of them is to isolate from microbes the chemicals insisted on by Liebig.

Thus on the main issue agreement was easy to secure, but certain relatively minor points remained unsettled; to one of these space must be devoted here, since it concerns the substance later known as "Bios." In his early paper on fermentation,[3] Pasteur described experiments in which a solution containing only water, sugar, yeast-ash, and ammonium tartrate was inoculated with "traces of beer-yeast," washed, of the size of a pinhead. He says, in part,

> After 24–36 hours microscopic bubbles of carbon dioxide appeared, and on the following days foam filled the flask and a deposit covered its bottom. Under the microscope a drop of this deposit revealed beautiful yeast-cells, much bunched and extremely young in looks, that is, the globules were turbid-translucent and non-granular; among these could be distinguished with surprising ease each globule of the small quantity of yeast used as seed; the young cells were infinitely more numerous than the old..... It must not be thought that in this solution fermentation ever became so active as it did when in place of using ammonia as the source of nitrogen, a suitable albuminoid substance was employed, such as that of grapes, beet juice, or yeast water. In sugar solutions containing one of these albuminoids fermentation was much more active; instead of after 36–48 hours, the first small bubbles appeared in 12–24, and much more yeast was formed in any given time. Nothing is more curious than this influence of the composition of the medium on the activity of the fermentation, and I have made a number of experiments on the matter. I was much surprised to find that in a medium formed

[2] J. v. Liebig, *Ann. Chem. Pharm.*, **153,** 1 (1870).

[3] L. Pasteur, *Ann. Chim. Phys.*, 3d ser., **58,** 323 (1860).

by dissolving sugar in a filtered solution of albumen from the whites of eggs, yeast cells will not bud at all, and there is no trace of fermentation.....when blood-serum is used, or juices squeezed from muscles, the cells develop with marvelous ease and the sugar ferments almost as well as in a natural saccharine juice or clear yeast-water; this is not because the albumen of eggs differs from that of serum, but because blood contains other albuminoid constituents which by their special nature are suitable for the nourishment of yeast; for if the blood be coagulated, boiled with water and then filtered to remove the coagulated albumen, sugar dissolved in the limpid filtrate forms a medium in which yeast multiplies and gives rise to well-characterized alcoholic fermentation; while if white-of-egg be treated in the same way, no fermentation at all occurs. These experiments were repeated many times, and always gave the same results.....It is obvious that there may be very great differences between members of the group called albuminoids or proteids. I have also observed that certain proteids are much more favorable than others to the development of the lactic acid ferment; for example, the soluble part of gluten or casein, the nitrogenous residue of liquids in which alcoholic fermentation has taken place, etc.

These quotations, though much abbreviated, make it very clear that Pasteur recognized the importance of some, but not all, "albuminoid materials" in the nutrition of yeast and other microbes. Liebig went further and questioned the possibility of cultivating yeast at all without them; when his own experiments with sugar, yeast ash, and ammonium tartrate gave negative results, and those of Naegeli the same, he did not hesitate to say that Pasteur had deceived himself, and what he took for yeast must have been something else. A prompt challenge "Come to Paris and see for yourself"[4] was the reply; coupled with a guarantee to prepare before his very eyes from salts brought with him "any reasonable quantity of beer yeast that Mr. Liebig may require."[4] This was in 1872, the year after "the war," Liebig was an old man, and the invitation was not accepted; consequently Pasteur was regarded as having "won" and for thirty years no more was heard of the affair; but the point at issue had not been settled; such "victories" do not last.

In 1901 in Ide's laboratory at Louvain, E. Wildiers[5] found he could not raise a healthy crop of yeast in salts-and-sugar solutions unless a little wort, yeast water, peptone, or extract of beef were added. The unknown substance—"perhaps a whole category of substances"—which so improves the medium, he called, provisionally, "Bios;" and expressed the hope that it might soon receive a chemical name. Thus the new word "Bios" was defined; and all who say "no doubt some chemical in wort makes all the difference, but it need not be Bios" have qualified to join the Last Ditch Bacon Club, which holds that Shakespeare's plays were written not by Shakespeare, but by some other bearing the same name. The existence of Bios, so defined, had obviously been recognized by Pasteur long before; the name is due to Wildiers, and so are the first attempts at chemical identi-

[4] L. Pasteur, *Ann. Chim. Phys.*, 4th ser., **25,** 145 (1872).
[5] E. Wildiers, *La Cellule*, **18,** 313 (1901).

fication: by weighing the carbon dioxide evolved when different media were inoculated with the same amount of yeast he showed that Bios is not contained in yeast ash, neither is it urea, aniline, tyrosine, adenine, guanine, creatine, edestine, ovalbumin, nor nucleic acid; for none of these substances can take the place of wort, yeast water, peptone, or extract of beef. Similar experiments showed that Bios diffuses readily through parchment paper, that it is not destroyed by half an hour's boiling in ten per cent sulfuric acid though caustic soda hurts it, that it is insoluble in ether and in absolute alcohol, that it is not precipitated by acetate of lead, and that addition of phosphotungstic acid, phosphomolybdic acid, basic acetate of lead, nitrate of silver or corrosive sublimate to the filtrate from the lead acetate precipitate leaves the Bios in solution.

The conclusions drawn from scientific work, rather than the facts established, attract attention; and those to whom the conclusions are unwelcome often dispute the facts. Darwin's conclusions as to the Descent of Man, for instance, awakened furious interest in butterflies and in the breeding of cattle among people whose indifference to such matters had previously been lifelong and profound. Wildiers' paper in a narrower circle had a similar effect; for though he had observed that in solutions free from Bios yeast will reproduce and sugar be destroyed, yet in his experience these changes were so slow and the new yeast so unhealthy that he felt compelled to seek in bad technic an explanation of Pasteur's results and thus, reluctantly we are told,[6] to side with Liebig. At once his facts were called in question, the real importance of his work explained away.

Krieger[7] in "Der Amerikanische Bierbrauer"—archaic title—and others following him, found a contradiction in the fact that while yeast water contains Bios, yeast grown by Wildiers in a yeast-water medium contained but little; although all interested, one would think, should know that the composition of a crop of yeast—even its nitrogen content—is not invariable.

Fernbach[8] suggested that the efficacy of yeast water and of wort in Wildiers' cultures might have been due to some hypothetical antidote they contained which might have neutralized equally hypothetical poisons adhering to his salts and sugar. This suggestion, put forward without experiments, was taken up by Windisch[9] who likewise furnished none; the hard work of the laboratory was left to Louvain, where Amand[10] proved equal to the task of refutation.

[6] P. Lindner, *Deut. Essigind.*, **24,** 103 (1920).

[7] Krieger, *Amerk. Bierbrauer,* **1901,** p. 712.

[8] A. Fernbach, *Ann. Brasserie et Distillerie,* **1901,** p. 510; this volume seems not to be accessible in N. America, but F. is fully quoted by Windisch (see [9]).

[9] W. Windisch, *Wochens. f. Brauerei,* **19,** 2 (1902).

[10] A. Amand, *La Cellule,* **20,** 225 (1902).

Some argued as though Wildiers said, "A few cells will not grow where many will;" his own words were, "Media in which development takes place slowly are poor media. . . . It cannot be admitted that these great differences in the march of fermentation and development depend only on whether 10,000 cells or 50,000 have been used as seed; if the cells have all they need the ten thousand should at most be but a few hours behind the fifty thousand." It is quite true that in the experiments of Wildiers' Table I, seeding with two drops failed while five drops grew; but these were drops of yeast suspended in rich wort, and Wildiers' whole contention was that the Bios in this wort made all the difference. Lafar[11] as well as Pringsheim seems to have misread here; while Naumann's observation[12] that five cells died in media where fifty grew, and Lindner's analysis[6] of Naumann's results, though interesting and important, are quite irrelevant, for in no experiment of which Wildiers gives details can he have used less than a million cells as seed.

Unless one brings the angels in again it is hard to say why Henneberg[13] omits all reference to Bios where he shows that adding peptone makes a twenty-five-fold transplantation possible, while without it none of his yeasts stood more than three or four; or why Pringsheim,[11] who recognized that yeast water is "an excellent culture-medium for yeast" should thus cry down the first attempt to isolate its active agent: "Science has been enriched by Wildiers with a new conception, Bios, in plain German, an Elixir of Life." Professor Ide's temperate reply[14] to some of these criticisms brought no recantations; the "contradiction," the unfavorable conditions in which "small seedlings" find themselves, and the "oligodynamic action" of possible poisons were still discussed; as Pasteur put it, "Nothing is so subtle as the argumentation of a dying theory." Windisch[15] even tried to explain away Wildiers' results by assuming a trace of copper in his distilled water, although Krüger[16] had shown that in such small amounts copper actually promotes the growth of yeast. Then, without apology, the opposition died away; not that new arguments were either found or needed, but because a new standard of probability had slipped in. The *Vitamins*, of which Bios was the first, received a group name; it could not be denied that small quantities of unknown organic chemicals were necessary for the healthy life of certain animals, and if for animals why not for yeast? Comparing small with great again, the

[11] Lafar, quoted by H. Pringsheim, *Centr. Bakt. Abt.*, **16,** 111 (1906).

[12] H. Naumann, *Z. tech. Biol.*, **7,** 1 (1919).

[13] W. Henneberg, *Wochens. f. Brauerei*, **24,** 612, 619, 620 (1907).

[14] M. Ide, *Cent. Bakt. Abt.*, **18,** 193; see also *J. Biol. Chem.*, **46,** 521 (1921).

[15] W. Windisch, *Wochens. f. Brauerei*, **19,** 527 (1902).

[16] F. Krüger, *Cent. Bakt. Abt.*, **1,** 10 (1895).

"Bios Question" with the "Witchcraft Question," one thinks of Lecky's words:[17]

> Disbelief in witchcraft was the result not of any series of definite arguments or new discoveries, but of a fundamental, insensible, yet profound modification of the habits of thought prevailing in Europe.... If we ask what new arguments were discovered during the decadence of the belief, we must admit that they were quite inadequate to account for the change..... the movement was mainly silent, unargumentative, and insensible; men came gradually to disbelieve in witchcraft because they came gradually to look upon it as absurd.

At first, of course, the revolution went too far. Kurono[18] showed that rice polishings which contain the anti-beriberi vitamin also promote the multiplication of yeast, and Williams, who obtained similar results with other natural products, assumed that Bios is identical with Vitamin B, and published[19] a" quantitative method for the determination of vitamin" based on measurement of the yeast crop. Eddy and Stevenson[20] took the same view, and so did Swoboda[21] and, at first, Funk and Dubin;[22] within a year or two, however, the distinction was restored, for Emmett,[23] Fleming,[24] Fulmer,[25] Funk, and others found preparations which promoted yeast production but failed to cure polyneuritic pigeons or aid the growth of rats, and vice versa. Thus, twenty years after Wildiers' work, sixty after Pasteur's, Bios "arrived;" though Funk's suggestion to rename it *Vitamin D* has not been taken up.

Now that Bios is accepted, what of the Liebig-Pasteur quarrel? How explain Pasteur's success and Liebig's failure to secure a yeast crop in the tartrate medium? Liebig's suggestion that Pasteur could not distinguish yeast from lactic acid microbe may be dismissed at once; the microscope was Pasteur's favorite tool. Wildiers' explanation that Pasteur added Bios with his yeast requires that Pasteur's pins had heads of more than 0.1 cc. in volume, for two drops of Wildiers' own "strong wort" were insufficient to cause healthy growth. That Liebig failed because he used too little yeast for seed can hardly be maintained; to him a pin-head meant 2 mm.^{3}, he tells us so, and also that he used one-tenth of this amount—about a million cells—for seed. Lindner's suggestion that perhaps Liebig's solutions were better supplied with air than were Pasteur's, and that this might

[17] Lecky, "History of the Rise and Influence of the Spirit of Rationalism in Europe," Vol. 1, Appleton, New York, **1891**, pp. 35–7.

[18] K. Kurono, *J. Coll. Agr. Imp. Univ. Japan*, **5**, 305 (1905).

[19] R. Williams, *J. Biol. Chem.*, **42**, 259 (1920).

[20] W. H. Eddy and Stevenson, *Ibid.*, **43**, 295 (1920).

[21] F. Swoboda, *Ibid.*, **44**, 531 (1920).

[22] Funk and Dubin, *Ibid.*, **44**, 487 (1920).

[23] A. D. Emmett and Stockholm, *Ibid.*, **43**, 287 (1920).

[24] W. D. Fleming, *Ibid.*, **49**, 119 (1921).

[25] E. I. Fulmer and Nelson, *Ibid.*, **51**, 77 (1922).

have caused fatty degeneration of the yeast he used for seed, is of course no better than a guess. Kossowicz's[26] discovery, on the other hand, that bacteria in a yeast culture may generate Bios there, offers a plausible explanation of Pasteur's famous crop; for it was only after 1860 that the technic of pure cultures was developed. The explanation that to me seems likeliest, however, is founded on a difference long ignored: in those early days they spoke of "beer yeast," implying[27] as it were that "pigs is pigs;" the fact that Liebig used a Munich bottom-yeast seemed unimportant, at least no one for many years suggested that the race of yeast employed might make a difference. Wildiers, who worked with "various commercial yeasts" and two pure races, thought he had proved the need of Bios to be "a general characteristic of all beer yeasts;" and this conclusion was supported by the work, though not the words, of Henneberg. Fulmer,[28] however, found a yeast in Fleischmann's yeast cake which he kept alive and well more than a year, by constantly transplanting in his Medium F made up of inorganic salts and sugar, although the crops were always less than those in wort; to make quite sure that Bios was excluded, cane sugar was replaced by methose (a synthetic sugar) and the yeast flourished as before. This shows there is at least one yeast that gives fair crops in media free from Bios; might not Pasteur's have been another?

Is the Bios question then completely answered? Chemists will not think so until the substance or "whole category of substances" that so improve the culture media for yeast have been isolated and identified. The first attempts to isolate Bios from yeast itself were made at Louvain by Ide's students, Wildiers and Devloo;[29] and though they were not crowned by the isolation of a chemical individual, they led Professor Ide to conclude that the active substance must be some derivative of lecithin-like fats, closely related to choline. In Prague, Lepeschkin[30] found that Funk's "crystallized vitamin" (prepared from yeast) increases the yeast crop, and Eddy in New York that Mueller's thio-amino acid[31] (from casein, etc.) has the same effect; these two with Eddy's "Bios 223" or "α-Bios," a crystalline substance with definite melting point and composition (pre-

[26] A. Kossowicz, *Z. Landw. Versuchsweses Oesterr.*, **6,** 27 (1903) and **17,** 688 (1906); cited from F. W. Tanner, "The Bios Question," *Chem. Rev.*, **1,** 397 (Jan., 1925), a valuable review which closes with a bibliography of 144 titles.

[27] "German authors distinguish two species of yeast, top-yeast and bottom-yeast, the latter of which is used in making Bavarian beer....and develops by granulations....I cannot go too far in expressing an opinion on facts I perhaps have never met with....but cannot avoid expressing doubt as to the existence of these two kinds of beer-yeast," L. Pasteur, in "Life of Pasteur," *loc. cit.*, p. 396.

[28] E. I. Fulmer, Nelson, and White, *J. Biol. Chem.*, **57,** 397 (1923).

[29] R. Devloo, *La Cellule*, **23,** 361 (1906).

[30] V. Lepeschkin, *Am. J. Bot.*, **11,** 164 (1924).

[31] J. H. Mueller, *J. Biol. Chem.*, **56,** 157 (1923).

pared from yeast),[32] and Kinugasa's product, seem to be the only definite chemical compounds hitherto discovered to have "the properties of Bios;" although Kerr[33] has obtained his "β-Bios" (from yeast) as a hygroscopic white powder, and Williams[34] has prepared a potent extract, Z_2, also from yeast. In Japan Suzuki[35] has identified the products formed by treating his "crude Bios" with an alkali, and long-continued work with rice-bran has led to the isolation by Kinugasa[36] of a compound $C_{10}H_8N_4$ "possessing strong Bios activity." Bios from other sources has been studied in Toronto, where Lucas[37] found that from wort two different substances can be prepared, one precipitated by baryta in alcoholic solution, the other not; Miss Eastcott[38] has identified the first of these with inactive inositol, Lucas called it "Bios I;" the second, called by Lucas "Bios II," has not yet been obtained as a chemical individual though Sparling's discovery of a volatile product of acetylation[39] from which the Bios II can be recovered gives some ground for hope. Addition of inositol to a salts-and-sugar medium has little or no effect upon the yeast crop, and so this substance is not Bios as defined by Wildiers. Addition of Bios II, on the other hand, does somewhat increase the crop; Lucas was inclined to ascribe this effect to contamination of his Bios II with inositol, for the most important point brought out in his paper is that adding inositol to a medium containing Bios II adds greatly to the crop obtainable with Bios II alone, and brings the yield almost to that obtainable from the amount of wort from which the inositol and Bios II were made. This he expressed by saying that the Bios in the wort is composed of two constituents, neither of which by itself has any great influence on the crop; a natural way to put it, one would have thought, and hard to misunderstand.[40] Since then, six other vegetable products—orange juice, infusion of rice-polishings, etc.—have been similarly fractionated, so this property is not confined to Bios from a single source; and Williams[41] has prepared from yeast by fuller's earth two extracts, both of which together give a large yeast crop while singly they do not. This year in Oxford Vera Reader[42] has discovered a similar case: "torulin" from yeast increases the *streptothrix corallinus* crop in salts-and-sugar media,

[32] W. H. Eddy, Kerr, and Williams, *J. Am. Chem. Soc.*, **46,** 2846 (1924).

[33] R. W. Kerr, *Proc. Soc. Exp. Biol.*, **25,** 344 (1928).

[34] R. J. Williams, Warner, and Roehm, *J. Am. Chem. Soc.*, **51,** 2764 (1929).

[35] B. Suzuki, *Proc. Imp. Acad. Japan*, **3,** 521 (1928) and **4,** 158 (1928).

[36] Y. Kinugasa, *Chem. Abst.*, **1928,** p. 3915, from *J. Pharm. Soc. Japan*, **48,** 539 (1928).

[37] G. H. W. Lucas, *J. Phys. Chem.*, **28,** 1180 (1924).

[38] E. V. Eastcott, *Ibid.*, **32,** 1094 (1928).

[39] E. M. Sparling, *Trans. Roy. Soc. Canada*, **22,** 271 (1928).

[40] E. V. Eastcott, *J. Am. Chem. Soc.*, **51,** 2773 (footnote) (1929).

[41] R. J. Williams, Wilson, and v. d. Ahe, *Ibid*, **49,** 227 (1927).

[42] V. Reader, *Biochem. J.*, **23,** 61 (1929).

while mannitol does not, but in a medium containing torulin as well as salts and sugar the crop is much increased by adding mannitol.

Although so little yet is known about the chemistry of Bios, some early expectations must be given up. Practically every one who worked upon this subject has added to the list of chemicals that do *not* help the yeast to reproduce: Pasteur showed that Bios is not egg-albumen, Wildiers' list is given above, Devloo tried alkaloids without success and derivatives of choline, Willaman and Olsen[43] tested nineteen compounds without luck; by these and others, representatives of all the major chemical families have been tried. On the other hand more than a hundred animal and vegetable juices and extracts have been found greatly to increase the yeast crop. The inference seemed not unjustified that Bios when it once was isolated would prove to be the prototype of some new group of compounds, which might include the vitamins, and which in any case could hardly fail to be of first-rate physiological importance; extension of the work with inositol and mannitol somewhat dims these hopes. Inactive inositol is a chemical widely distributed in animals and plants, occurring where cell reproduction is most active, disappearing from the ripening seed and reappearing when the same seed sprouts; added to media containing Bios II it greatly helps the yeast to reproduce, but the closely allied quercitol cannot take its place, neither can quebrachitol nor scyllitol, specimens of which were kindly sent last year from Montreal and Cambridge to Toronto, nor the product of hydrolysis of the former; although scyllitol is a stereo-isomer of inositol, and the other is the methyl ether of *l*-inositol. Mannitol which with *streptothrix* plays much the part of *i*-inositol with yeast cannot replace the latter, neither can a dozen other polyalcohols and sugars Miss Eastcott tried last winter. Miss Reader had the same experience; she found that neither inositol, dulcitol, sorbitol, nor glycerol could take the place of mannitol in her *streptothrix* media. In this respect the chemicals seem very individualistic, so do the microbes, and even the various races of yeast; Eddy's crystalline Bios makes very little difference in the crop of the yeast used in Toronto, Peskett[44] found the same with his variety of yeast, and Eddy himself reports better results with top-yeasts than with bottom-yeasts. Closer comparisons are not possible at present, and will not be until those working in the different laboratories agree upon a common way of measuring the efficiency of their preparations.

How far have we advanced since Pasteur showed the way? We have a name, accepted after much resistance, which at all events is better than "albuminoid material" or "vitamin" since it does not prejudge the outcome of chemical investigation; and the chemical study of Bios has spread

[43] J. J. Willaman and Olsen, *J. Biol. Chem.*, **55,** 815 (1923).

[44] G. L. Peskett, *Biochem. J.*, **18,** 866 (1924).

in all directions from Louvain. Moreover, in these seventy years methods of measuring the rates of chemical changes have been developed—the pioneer work of Harcourt and Esson came out in 1866—so that in our days the rate of reproduction of yeast in various media can profitably be studied as a problem in the kinetics of an autocatalytic reaction in a heterogeneous system along well-established lines. Four factors fix the rate of budding: (*i*) the race of yeast, (*ii*) the physiological state of the yeast-cells, (*iii*) the temperature, and (*iv*) the composition of the culture medium immediately surrounding the cells. A word or two on each of these in turn: (*i*) Lucas[37] compared Toronto yeast with two races brought by Professor Eddy to the B. A. meeting 1924; both gave larger crops with Bios, but one a larger crop without the Bios than the other with it. (*ii*) According to Buchanan,[45] the life history of a typical yeast culture begins with a period of quiescence, budding then sets in, slow at first but gradually faster until "the stage of logarithmic growth" is reached during which the number of new cells formed per hour is proportional to the total number present; the rate of reproduction then falls off, and in the last stage more cells die than new are formed. One would almost think yeast cells grew old, as men do; the difference is that in the case of yeast the stage of healthy youth, the "logarithmic stage," can be indefinitely prolonged by frequent transplantation into fresh culture fluid, and the first two stages can be avoided altogether by use of active yeast for seed; from this it follows that the stages of senescence must be due either to depletion of the nutrients or to accumulation of poisons, such as alcohol, in the surrounding fluid. (*iii*) Seventy years ago Pasteur left his cultures standing on a shelf, since then convenient thermostats have come in; temperature affects the rate. (*iv*) Lindner pointed out that in a heap of yeast the cells lack oxygen and are bathed in stronger alcohol and weaker nutrient than if more scattered; but Clark[46] seems to be the first who kept his cells suspended while they reproduced; this is so easy to accomplish—*e. g.*, by rocking in an L-shaped tube which aerates as well as stirs—and is so essential to the maintenance of logarithmic growth, that results obtained in any other manner need defending.

Working under these conditions—active seed yeast of a definite race, thermostat, and rocker-tube—Clark measured the effect of adding various quantities of wort to a salts-and-sugar medium. He used a yeast that budded very slowly without Bios, quickly in wort; so that before results were out it seemed as probable as not that where more wort was added reproduction would be faster; the event proved otherwise. Right from

[45] R. E. Buchanan, *J. Infect. Diseases*, **23,** 109 (1918); see also Buchanan and Fulmer, "Physiology and Biochemistry of Bacteria," Vol. I, Williams and Wilkins, Baltimore, **1928,** Chap. 2.

[46] N. A. Clark, *J. Phys. Chem.*, **26,** 42 (1922).

the time of seeding, the rate at which new cells were being formed at any moment was found to be proportional to the number of cells present at that moment in the tube; and so long as this logarithmic increase was maintained the rate was just the same as in pure wort. What happened later depended on how much wort was used; if much, the logarithmic stage persisted until 1.8% of alcohol was formed, and then fell slowly off—senescence due to poison; if little, then before this point was reached, the rate fell suddenly almost to zero—exhaustion of the Bios—and the crop was roughly proportional to the amount of wort employed.

These results fix the conditions of experimentation whether it be desired to compare the effects of a given preparation on different kinds of yeast or to compare the effects of different preparations on the same race. When, as in attempts at isolation, it is desired to estimate the amounts of Bios in a series of solutions, it is good sense to choose a yeast which buds slowly without the Bios and quickly with it; the seed employed must be from a culture in the logarithmic stage; and the amount of Bios added must be such that in the experiment logarithmic reproduction passes sharply into quiescence, not enough to prolong the logarithmic stage until accumulation of alcohol, etc., introduces complications. The slope of the logarithmic curve and the crop obtained when logarithmic reproduction ceases are the important matters; the former is characteristic for a given preparation, and the latter measures the amount of active substance present, or if there be more than one, that of the active substance present in (physiologically) the least amount—in media containing inositol and Bios II, for instance, the slope is independent of the amount of either, and changes sharply when either is used up. If a suitable race of yeast be used, the crop increases so slowly when the logarithmic stage is passed that a few hours' delay in measuring it is of no practical importance. Clark used a quarter-million cells per cc. as his seeding; if half as much be taken, logarithmic reproduction lasts about two hours longer, but in the end gives the same crop; this shows how little information is conveyed by such a statement as "the yeast increased ten-fold."

The history of Bios seems to date from Pasteur's work on fermentation; then came the unspoken false assumption that all yeasts act alike, Liebig's attack, and Pasteur's challenge, which in the circumstances of the day roused feelings we must hold responsible for much unprofitable opposition to Louvain. At last, progress in other fields—discovery of the vitamins, development of the methods of chemical kinetics—has put the subject in its true perspective, set chemists working on three continents, and points the way by which the Bios problem can be solved.

MADAME MARIE CURIE DEDICATES HEPBURN HALL OF CHEMISTRY AT ST. LAWRENCE UNIVERSITY*

The Hepburn Hall of Chemistry, a gift of Mrs. Emily Eaton Hepburn of New York City, was dedicated at St. Lawrence University, Canton, New York, on October 26, 1929, by Mme. Marie Curie, co-discoverer of radium. Prior to the dedication ceremony, Mme. Curie received the honorary degree of Doctor of Science at the hands of President Richard Eddy Sykes. Dr. George B. Pegram, professor of physics and dean of the faculty of engineering, Columbia University, delivered the following address at this presentation.

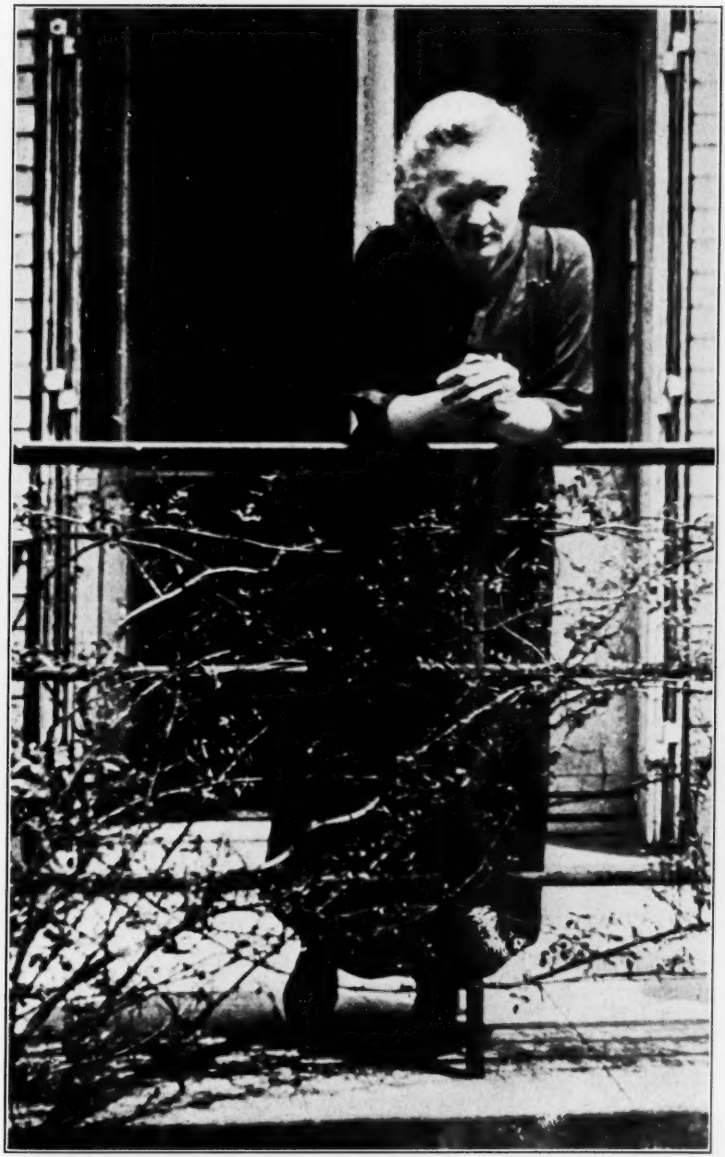
ENROUTE TO EXERCISES
Left—President R. E. Sykes. *Next*—Madame Curie.
Next—Owen D. Young.

MR. PRESIDENT OF THE CORPORATION, MR. PRESIDENT OF THE UNIVERSITY, HONORED GUEST, MEMBERS AND FRIENDS OF THE UNIVERSITY: In trying humbly to utter on this occasion some brief appraisal of the work of the great and universally honored scientist to whom this university is to give the tribute of its honorary degree, I must clearly not attempt to speak of the whole of Madame Curie's achievements and life. Too much would need to be said of the inspiring example of her life, of her unswerving devotion to scientific research, of her patriotic and humanitarian service. Too much would need to be said of the consequence to knowledge and to human welfare.

The theme on which I shall attempt briefly to speak is: "Marie Curie, the discoverer."

In any scientific discovery, that is, in its incidence here or there, there is an element of chance, of good fortune, of luck. It was so in the case of the chief discoveries of Madame Curie, the discoveries first of polonium and then of radium. A year earlier in Paris Professor Becquerel had discovered the property of the element uranium, of

* The material and several of the photographs used in this account were obtained for us by Professor Verner J. Warner of the Department of Fine Arts, St. Lawrence University, Canton, N. Y.



Underwood & Underwood

MADAME CURIE RESTING OUTSIDE HER LABORATORY IN PARIS

giving off faint radiation of a new kind, a property named radioactivity. The subject was in the air, in the scientific atmosphere, in that city. Madame Curie and her illustrious husband could not escape it. She fell into step. Madame Curie discovered radium, but any one who knows what was going on at the time knows that if she had not made the discovery some other person would certainly have made it within a very few years. She was clearly fortunate.

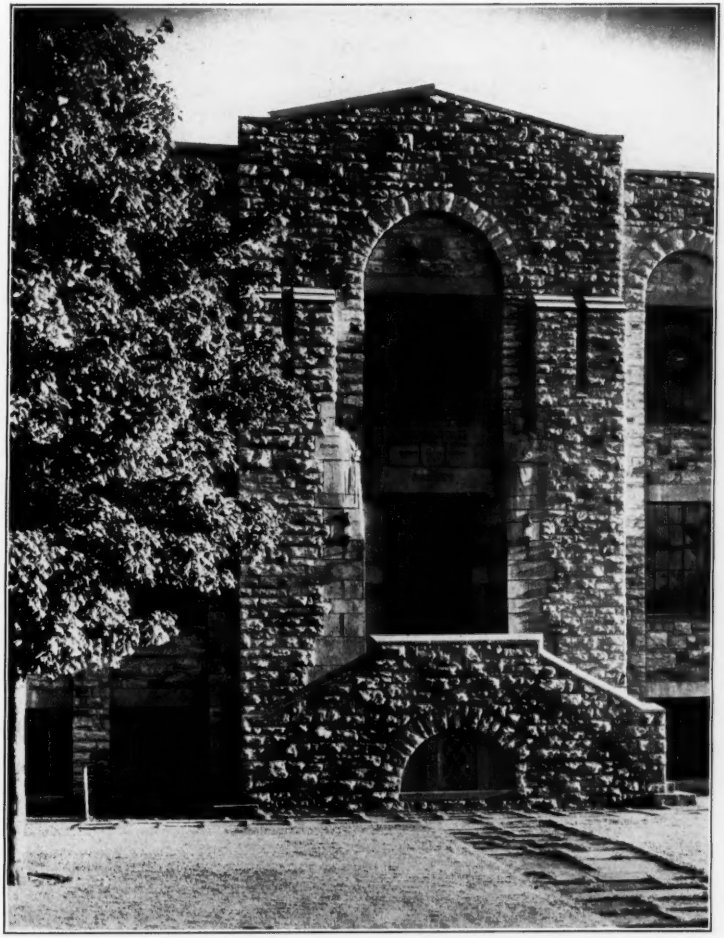
Let us compare some other discoveries. In the laboratory of the Royal Institution in London, in 1831, there worked a man who had been trained under the great master in research, Sir Humphry Davy. This man had at his command as good a laboratory as existed in England, he had before him the experiments of Oersted and the clarifying researches of Ampere on the interaction of electric currents and magnets; he went just a step further and found that by moving a magnet he could generate an electric current. The time was ripe for this discovery. If Faraday had not done this some one else would have done it within two or three years (our own American Professor Henry actually was doing it). From that discovery which Faraday had the good luck to make flowed the whole development of electric energy of today—capitalized now at more than forty billions of dollars, as President Hoover recently told us. Michael Faraday was fortunate. He was lucky as to time and place.

In 1895 a professor in Würzburg was working with electric discharges in highly exhausted vessels. He studied the streams of negative particles, the cathode rays of Crookes. He had by him a card covered with crystals that were known to glow when struck by the invisible cathode rays inside an exhausted vessel. Suddenly he found that invisible and penetrating radiation came right out through the glass of the cathode ray tube and caused the screen of crystals near it to glow. The X-rays were discovered. Was not Professor Röntgen a lucky man? If he had not then discovered this wonderful radiation, some one else would have done it very soon.

In 1905 the failure of the Michelson-Morley experiment to detect any motion of the earth through the luminiferous ether had long been discussed. Larmor in England and the great Lorentz in Holland had recently succeeded in showing that if the interatomic forces are electrical all bodies in motion would appear to shorten and for that reason the Michelson-Morley experiment would necessarily show no ether drift. Then came Albert Einstein, who brought forth the relativity theory by taking only a short step, but a magnificently bold one, beyond the formulation of Lorentz. Einstein was fortunate. Without Einstein the discovery of the relativity theory would surely have come within five years or less. The stage was set.

Chance played the same part in Madame Curie's great discovery as it did with Faraday, with Röntgen, with Einstein. It played the same part as it does in the arrival of a great steamer in port. To an observer on Mars it might seem just good luck that the *Mauretania* after crossing the Atlantic strikes the continent just where it finds the opening of New York bay: but we know the navigator and the pilot have guided it. Faraday had guided himself through long and zealous training to the port of discovery. Röntgen's preparation was long and thorough. Einstein had followed his zest for problems of physics through a vigorous course of training and development. Madame Curie had moved steadily toward her great feats from the time she trained herself as a chemist under her own father's tutelage, through her selection of Paris and its university for her further training and environment, and her association in work with her distinguished husband, to the fulfilment of her self-shaped destiny.

In the next place let us recall how simple are the truly great discoveries of science. The Copernicans discovered the very obvious fact that it is simpler to view the earth and the planets as moving around the sun than to describe the peculiar motion of the planets with reference to the earth. Galileo discovered the very simple arrangement of



MAIN ENTRANCE OF HEPBURN HALL OF CHEMISTRY, ST. LAWRENCE UNIVERSITY, CANTON, NEW YORK

Note bas-relief of Mme. Curie at right of entrance and, opposite, that of the physicist Dalton.

two lenses that makes a telescope and it opened up the heavens. Newton's laws of motion are in essence the simplest possible statement of principles in mechanics, and his identification of the force that holds the moon in its orbit with ordinary weight is simplicity itself. Faraday's generation of electric current by the motion of a magnet was seen by him to be a necessary and simple consequence of the magnetization of a piece of iron placed in a coil carrying a current. Rutherford pictured a nuclear or solar system atom with a central body of positive protons and some negative electrons and with relatively far-away electrons in planetary orbits about the nucleus. It is so simple a structure that when Bohr added the quantum concept to the picture the simplicity of the relations resolved at once the tangle of the lines of the spectra and the structure of the atoms of all the chemical elements. Einstein did not, as is sometimes popularly alleged, come to glory because he achieved a theory so abstruse that few could understand it. Einstein recast the whole of theoretical physics by a postulate, that of the special relativity theory, so simple, so in line with all our experience, that the wonder is that it was not recognized before. The underlying idea of his general relativity theory is just as simple.

Any one can build up valueless and patchwork theory. It is the genius of the great discoverer to discard the patchwork and to show how phenomena are to be described in terms of the fewest concepts and principles.

Madame Curie's discovery of polonium and radium is one of the finest examples of this clear-seeing, simplifying insight of scientific genius. She saw that the newly discovered radioactivity was an atomic property of the element uranium, that chemical combination with other elements did not increase or decrease it; she found also that certain uranium ores of known chemical composition were more strongly radioactive than could be accounted for by the amount of uranium present. When she put these facts together she knew that some radioactive substance other than uranium must be in the ore; she knew that it must be far more intensely radioactive than uranium because it was present in such small amount that chemical analysis had not shown it. Radium was discovered. It was separated out by ordinary chemical methods and the purification was a long and beautiful piece of work, but the discovery itself was marked by the same direct obviousness that marked Newton's discovery of the law of gravitation, Faraday's discovery of induced current, Einstein's discovery of the relativity principle.

Then there is one other mark of genius in a discoverer—the imagination to evaluate with prophetic vision the consequences of the solution of the problem to which he gives attention. Newton might well have found much else to occupy his mind than the motion of the moon, Faraday might well have kept on with his highly fruitful chemical studies instead of turning to electric circuits and magnets, Einstein might well have given up his long devotion to the problem of the experiment to detect motion through the ether—his best friends urged him to give it up—Madame Curie could easily have kept busy with investigating the radioactivity of uranium without looking for anything a million times more radioactive than uranium. They did not—she did not, and great discoveries came.

While, therefore, we with the rest of the world honor our guest for her whole life, her steadfast devotion to science, her modesty—honor her as wife and mother—honor her for her unselfish gifts of means and of patriotic service, and while indeed the nobility of her life has been such that our admiration for her character almost draws our attention away from the essentials of her scientific works, it is most appropriate for us on this academic occasion to honor one who was fortunate because prepared, who has penetrated mysteries with the simple insight of genius, who has discerned values with prophetic imagination—to honor Marie Curie, the discoverer.

Underwood & Underwood

MME. CURIE IN HER LABORATORY IN THE EARLY DAYS OF EXPERIMENTATION

AT THE DEDICATION EXERCISES
Standing—Owen D. Young. *Seated*—Mrs. Emily E. Hepburn.

President Sykes then conferred the honorary degree on the University's distinguished guest with the following citation:

Mme. Sklodowska Curie, self-effacing and devoted scientist, teacher, and author, exemplar of the art of living while directing to beneficent ends powerful forces of nature, single and persistent in purpose, triumphant in research, hastening the march of civilization by the discovery of radium, inspired and inspiring idealist, practical dreamer, I confer upon you the honorary degree of Doctor of Science, with all the rights and privileges pertaining thereto.

These exercises concluded, the Hepburn Hall of Chemistry was presented to the University by Mrs. Emily E. Hepburn, who spoke as follows:

St. Lawrence University is a college that is undertaking to interest its students in the important things of life. The problem is to find them, recognize them, and give them proper values. In times past a knowledge of religion, literature, Latin, and Greek were considered the essentials. Science was a dangerous subject that was attacking the religious traditions of many generations. Science and religion were not congenial, and some adjustments had to be made. The word science means *to know*. The great truths that have been discovered by scientific investigations have placed science among the essentials of life.

Chemistry, perhaps, has taken the lead among the sciences. It plays an important part in every phase of human life. Every article of commerce that supplies the needs of the millions of people of the world has a contact with chemistry. In order that chemistry may fulfil its mission, great experimentation must be done by students

who have a keen interest in the subject. I wish to tell you of the content of a letter received by Dean Hulett, a former professor of chemistry of St. Lawrence University, from a student, prompted by the announcement of the visit of Mme. Curie to our college:

"DEAR DEAN HULETT:

"The following clipping about Mme. Curie is twenty years old. Just a few minutes ago I found it in my chemistry notebook record of my sophomore year with you in chemistry in 1909. . . .It was the result of one of your lectures on Mme. Curie and the possibility of a greater knowledge of radioactivity that might bring about something the alchemists once dreamed of—the transmutation of metals.

"From this clipping from the magazine *Science and Discovery* of 1909, I wish to quote to you from Mme. Curie's own lecture her own words.

" 'It has been proved that radium, a perfectly definite chemical element, produces continually another perfectly definite chemical element, helium. It is admitted that helium is one of the products of the disintegration of the atom of radium and it is noteworthy that helium occurs in all the radium-bearing minerals.

'The theory of the radioactive transformation has been extended to all the radioactive bodies. Investigations have been made to determine if the radioactive substances heretofore considered to be elements are not to be derived from one another.

'The origin of radium itself has been sought in uranium. It is well known that radium is found in uranium-bearing minerals. It even appears from recent researches that proportion between the quantities of radium and uranium is the same in all these minerals. Uranium may then be thought of as another substance which disintegrates with extreme slowness, giving place to the production of radium and the products which succeed it. It appears also to be probable that the last term of the radioactive series is polonium.

'Under the picture of Mme. Curie which accompanied this clipping was this statement: Madame Marie Sklodowska Curie has just attracted fresh attention to her achievements as an investigator by the isolation of polonium. In isolating it she has demonstrated the importance of what is called the new physics.' "

Such was the quality of the teaching of chemistry in one room in Carnegie Hall twenty years ago. There is no telling what heights chemistry may reach with the facilities afforded in Hepburn Hall.

The coming of Mme. Curie to dedicate this Hall of Chemistry has given the students of St. Lawrence a high standard toward which they will strive. I join Mr. Hepburn in presenting to St. Lawrence University, my beloved Alma Mater, this Hall of Chemistry.

Owen D. Young, president of the Board of Trustees, then introduced the noted scientist to the friends and students assembled.

It is not so many months ago since I declared the corner stone of this building well and truly laid, and now I declare the building well and truly finished and ready for its dedication, and my first word must be of thanks to Mr. Hepburn, who, during his life, did so much and now today to Mrs. Hepburn who has carried on through these years in every way to help St. Lawrence. I assure her that we are grateful not only for this building, and what it means, but for all that she has done for this University. Certainly a science building, and particularly a chemistry building stands on this border line of the known and the unknown. So far as the students who enter it are concerned, almost everything is unknown. So far as those who leave it are concerned, much is unknown. But it also stands on the border line in another sense. From the standpoint of Madame Curie that is the line which exists between what is known and what is yet to be discovered. And so we are most fortunate today, not only in accepting this

physical building, but in being able to accept it with the christening of the most distinguished scientist living in the world today. She honors St. Lawrence by coming here. The christening which she shall give us, I promise her, will make one of our dearest and most cherished traditions from this time on, and now I have the honor of presenting this woman who has behind her all that is known and who has her face forward to all that is unknown—Madame Curie.

And Mme. Curie's few words, spoken in English, completed the dedicatory exercises.

I dedicate this laboratory to scientific research in the field of chemistry. It is a pleasure as well as an honor for me to have been asked to come to St. Lawrence University on this occasion. I appreciate highly this new important development of the University, and fully realize the need of it at a time when physics and chemistry are in constant and amazingly rapid progress. It gives confidence in the future of your University to know that as soon as the need has been made clear the new laboratory has been erected by the devotion of those who have been educated here. I am in sympathy with the feeling that, having received high education, one should have the desire to extend the same privilege to others. I also believe that pure scientific research is the true source of progress and civilization and that by creation of new centers the number of men and women who are able to devote themselves to science shall be increased. For all these reasons I congratulate St. Lawrence University on the opening of the new laboratory and I congratulate Mrs. Hepburn and Mr. Young for their part in this creation.

TO MADAME CURIE*

What age-long effort had essayed in vain
This woman wrought. She loosed the Gordian knot
That held the conquest of the world, and what
The frustrate alchemist could ne'er attain
She has achieved. She broke the primal chain
That binds the elements; she touched the spot
Where lies the hidden spring—and lo! the plot
And secret of the universe lay plain.
Yet what the alchemist in vain had sought
For greed and dazzled by the lure of gold,
She only that she might the truth unfold,
Still toiling for the love of man, has wrought.
Let all the ghosts of alchemy bow down,
While on this woman's brow we set the crown.

* Poem composed and read by Charles Kelsey Gaines, professor of English literature at St. Lawrence.

THE FRANCIS P. GARVAN CHAIR OF CHEMICAL EDUCATION*

Throughout the past academic year the department of chemistry of The Johns Hopkins University has been formulating and, as conditions permitted, putting into operation plans for the development of the work of this department. These plans look not so much to an increase in the work of the department as to an improvement in the student body and facilities for the research work of the staff and students. The realization of these aims evidently necessitates increased material assistance.

Briefly, the plans referred to involve first a method that will provide advanced students of real ability; secondly, a staff and equipment that will make it possible to give these men thorough training in the fundamental aspects of the science, not forgetting the necessity for their preparation in mathematics and physics; thirdly, the furnishing of an adequate equipment of apparatus to enable the staff and students to investigate problems in a great many lines of research and thus not restrict their research work to any definite field; and finally, the making it possible for the graduate students in chemistry to meet and hear those in this country and as far as possible those from abroad who are making worthwhile contributions to the science through their own researches.

The first impetus toward the carrying out of this program is due to the generosity and interest in chemical education of Mr. Francis P. Garvan, who founded in the department of chemistry a chair of chemical education. At the end of a year Mr. Garvan decided to endow this chair in his name and the exercises on the occasion of this endowment will be mentioned below.

Dr. Neil E. Gordon, editor of THIS JOURNAL and formerly head of the department of chemistry in the University of Maryland, was selected as the first occupant of this chair. Dr. Gordon is a graduate of the department of chemistry of The Johns Hopkins University, and familiar with its problems and traditions. He was therefore in a position to render immediate and valuable service in perfecting the plans outlined above and especially in securing the financial assistance necessary to putting these plans into operation. He has secured from individuals and corporations some twenty fellowships to support students while completing their graduate work in chemistry. The majority of these are state fellowships, each donor of a fellowship designating the state from which appointment to such fellowship is to be made. The list of fellowships now available is given below. It is essential that the student appointed should maintain an excellent standing in his work, for the department reserves the right at all times after his arrival to pass on his fitness to hold such fellowship. It is hoped that it will be possible to secure one such fellowship from each of the forty-eight states. Recommendation for appointment to these

* This account of the dedication exercises is essentially the one written by Dr. J. C. W. Frazer for *The Johns Hopkins Alumni Magazine*, **18**, 2–15 (Nov., 1929).

fellowships is made by a committee of three for each state. The donor in each case has the right to appoint one member of the committee. The Department of Chemistry appoints the other two. When a state fellowship is to be awarded a strenuous effort is made to put before the chemistry department of each college and university of that state all information possible relative to the fellowship with the hope that the state in this way will be thoroughly canvassed. When in normal operation twelve new students will be appointed each year and twelve will be leaving. This will mean that, with forty-eight states represented, the students in residence for a period of four years will be equally distributed from year to year. The first group of nine has already entered this fall. They are as follows: WILLARD E. BLEICK, Stevens Institute of Technology, *New Jersey;* ROBERT W. CAIRNS, Oberlin College, *Ohio;* MICHAEL S. EBERT, Lehigh University, *Pennsylvania*; THEODORE E. FIELD, Bates College, *Maine;* KENNETH E. GLIDDEN, University of New Hampshire, *New Hampshire;* MAURICE E. KRAHL, De Pauw University, *Indiana;* JOHN E. RUHOFF, University of Wisconsin, *Wisconsin;* ROBERT D. STIEHLER, Rensselaer Polytechnic Institute, *New York;* PAUL P. SUTTON, The Johns Hopkins University, *Maryland.*

All the information relating to each applicant comes to the department of chemistry in order to relieve the state committees of as much routine work as possible. When all applications have been received they, together with all letters and records relating to each applicant, are sent to the chairman of the proper committee, whose recommendation is finally sent to the department. Usually after the elimination of all but the last few applicants the committee asks for a personal interview with each. So far it has been a wonderful experience to see the interest individual donors have taken in this matter of selecting students, and also the interest and valuable services the members of the state committees have given. It is a real pleasure for the department of chemistry to acknowledge to these gentlemen the valuable help they have given us in this work. Much of the success of the plan is involved in the choice of the students brought to the University on these fellowships, a fact which the committees have fully realized.

Briefly, this is the plan by means of which it is hoped the number of high-grade students in the department will be increased.

The General Education Board has taken keen interest in the movement we have begun, and has generously consented to give the department of chemistry the sum of ten thousand dollars a year for four years to provide during this time the funds required for the purchase of special apparatus and supplies necessary for new lines of investigation to be begun. This, for the period mentioned, seems to be an adequate amount when taken together with that appropriated regularly by the University to provide for the research work contemplated.

And finally the gift of Dr. A. R. L. Dohme of the firm of Sharp & Dohme, Baltimore, an alumnus of the department, is sufficient to bring to the department one outside lecturer each month of the academic year. In this way the students will get an opportunity in the course of their four years' stay at the University to meet and hear most of the leading investigators.

From what has been said it is seen that within the space of one year considerable progress has been made in carrying out the plans outlined above. It is hoped that during the probation period of four years the donors who have contributed to the needs of this program, and The Johns Hopkins University will be mutually satisfied with what will have been done and means will be provided by the various donors to endow or continue indefinitely the assistance they have given.

The exercises commemorating the endowment of the Francis P. Garvan Chair of Chemical Education were held Friday, October 11th, in Remsen Hall. It had been Mr. Garvan's desire to be present on this occasion and to participate in the formal exercises. Unfortunately, he was prevented from doing so by a severe cold, but he sent an enthusiastic letter in which he expressed his great interest in the plans of the department.

Among those present on this occasion were some members of the Board of Trustees, many of the donors or officials of companies donating state fellowships, members of the state committees on fellowships, many friends of the department, and a large delegation from the student body.

President Ames presided at the exercises and addressed the audience as follows:

> We have invited a number of the friends of The Johns Hopkins University to meet today and be present at the inauguration of two new undertakings in the Department of Chemistry. These are of primary importance to the University, it is true; but they also affect the country as a whole, and especially many of our largest industries.
>
> I do not need to say much to those in this room in regard to the importance of chemistry in industries, in medicine, in daily life. Progress in the application of chemistry depends absolutely upon a continually new supply of young men and women trained in modern methods of research. The training of students involves two aspects, first, the selection of the students, and second, their training. Both aspects require careful consideration, and many questions are raised.
>
> I am convinced that the fundamental qualities required of a great teacher are: first, personality; second, the gift of originality and imagination; third, power to inspire students by the force of example; fourth, a consciousness of duty. It is the duty of a university to have such teachers. But, how about the students? I am very uncertain as to how we must proceed, not alone to select them but to train them. I am sure that the primary aim should be to recognize originality and then to give it scope to develop. Chemistry has so many sides that we must be sure that we do not block development in any direction.
>
> The undertaking in which we are now engaged is not merely a carefully planned project of this University, made possible by the generous coöperation of far-sighted, public-spirited individuals and organizations. It has a far deeper significance.

Many of us can remember the time when science was considered to have so little actual relation to practical life that the industrial control laboratory was scarcely considered a necessity, and the industrial research laboratory was looked upon as pure luxury. Times have indeed changed, for today it passes for a truism that industry can well afford to engage in, or to support, research in pure science, with good hope of generous ultimate return upon its investment.

But enlightenment has not ceased there. There is a growing consciousness that the support of research entails more than the building of laboratories and the purchase of apparatus and materials. We must give some thought to the selection and training of the scientific personnel which is to man those laboratories. We must look beyond that, even, to the recruiting of teachers of science who shall train others for the future.

Allied to the realization that I have outlined, there is a conviction that the hope of future advancement lies, not in the average student of today, but in the student of exceptional ability and character. No responsible person feels that the average student should be slighted—on the contrary he should be given every opportunity to develop his abilities to the full. But his abilities are not equal to all of the tasks which we hope to see performed. Our educational system must include some provision for complete utilization of the potentialities of the unusually gifted student.

These are some of the considerations which have actuated the founders of the present enterprise. I am aware that they consider it a privilege—some of them have said a duty as well—to give their ideas and ideals concrete form in this fashion. We of The Johns Hopkins University esteem it no less a privilege and a duty to serve as the instruments by means of which their sense of patriotic and social responsibility may find expression.

You will be interested to hear the names of the enlightened individuals and firms who are coöperating with us in our plans.[1] They are as follows:

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I have outlined briefly the various features of our plan, but I have not mentioned specifically its one vital part. That is the responsibility of the University. I assure you that we recognize this, and I am confident that your expectations and ours will be realized. I have only to mention the names of the men who will be the teachers and inspirational leaders of these Fellows for you to see how justified I am in my belief: Abel and Mansfield Clark in those fields touching the medical sciences; Reid and Rice in the organic field; Frazer, Patrick, Cartledge, and Thornton in the inorganic and physical field; Herzfeld and Andrews in the borderland of physics and mathematics; and Gordon in chemical education.

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particularly those who come to the University as state fellows under the scheme outlined above and who are appointed to such fellowships because of the belief that they are above the average in ability. The meeting was turned over at once to Dr. Gordon who conducted the discussion. There were present about fifty, among these a number of the donors of fellowships and members of the state fellowship committees, and a limited number interested in the purpose of the conference.

At 6.00 P.M. dinner was served in Levering Hall and shortly after, at eight o'clock, there followed the last feature on the program of the day. This was a public lecture in Remsen Hall by Dr. C. E. K. Mees of the Eastman Kodak Company. Dr. Mees' lecture was the first to be given under the A. R. L. Dohme lectureship. President Ames again presided and introduced Dr. Dohme who spoke briefly of his desire in providing the lectureship to make it possible for the student body to see and hear investigators in various fields. The lecture by Dr. Mees on "The Development of the Photographic Image" proved to be extremely interesting and was illustrated by a number of remarkable moving-picture illustrations of the development of the photographic image. The lecture, although popular in style, brought before the audience the modern work and theories which have been advanced to account for the facts relating to photography.

Thermionics Pioneer Given 1928 Nobel Physics Prize. The man who discovered the fundamental laws connecting the production of electricity from a hot wire with the temperature of the wire, a phenomenon utilized today by every tube radio set, received the 1928 Nobel prize, just awarded this year. He is Prof. Owen Williams Richardson, director of research in King's College, London, who from 1906 to 1913 was professor of physics at Princeton University in this country.

He is considered the father of the branch of physics which he christened—thermionics—which deals with the effect that heat has on matter in generating electrically charged particles, called ions or electrons. While Prof. Richardson's work for which he has received the Nobel prize was done in the interests of the advancement of pure knowledge, his laws find practical application in the design of electron tubes now so widely used in radio, the talkies, and other applications of physics to industry.—*Science Service*

The Kekulé Memorial Book. In celebration of the centenary of the birth of August Kekulé, the eminent German chemist (born on September 7, 1829, in Darmstadt), the Verlag Chemie G. m. b. H., of Berlin, has published a two-volume life, written by Professor R. Anschutz, one of Kekulé's students. The first volume (732 pp.) deals with Kekulé's life and work; the second (976 pp.) with his scientific papers, reports, articles, speeches, etc.; and the price is 120 marks. The production, printing, and binding of the volumes can only be described as sumptuous. The first is profusely illustrated, the pictures including not only Kekulé and his circle, but various groups of great interest. In the labor and care lavished on the production of these volumes, Professor Anschutz and the publishers have fittingly commemorated the immense services rendered by Kekulé to organic chemistry.—*Chem. Age*

THE EDUCATION OF THE SUPERIOR STUDENT*

JOHN J. ABEL, THE JOHNS HOPKINS SCHOOL OF MEDICINE, BALTIMORE, MARYLAND

The problem that we are to consider has no doubt occupied the minds of our ancestors since they first learned to fashion clubs and stone hatchets; it is still with us, and it is one that will always vex mankind. In the complex civilization of our day the question has become broader than ever. In one way or another, all of our numerous arts and industries, commerce and finance, schools of art, the various learned professions, our university institutes, as well as the research laboratories of our great industrial organizations must all concern themselves with the problem of how best to select and develop leaders whether for executive duties, or for scholarship and the extension of knowledge.

Even among the members of the animal kingdom other than the race of men, as birds and mammals, we find that the older generation has its troubles with the more stupid or refractory as well as the more gifted or adventuresome of the young. It is only among the social insects, bees, wasps, ants, and termites, with their wonderfully organized community life or state, with differentiated classes of citizens or castes, each member of which knows his duties from the moment of birth, that little or no concern with our problem is manifested. Here there is no need of instructors or classes, no long adolescence. The aptitudes of the members of each caste are predetermined by certain anatomical and physiological states of the ganglionic cell clusters that serve for a brain. Here are unrolled in a certain sequence all of the inherited memories or instincts—guiding forces for automatic behavior—and from here, naturally also, arise the nerve impulses that inaugurate such plastic or modifiable behavior as is sometimes observed among them. We have among these insects, then, a very perfectly organized state, a sort of Utopia. It is quite natural to dream of Utopias and to write about them, as many have done in the past, and I suspect that some of our educational authorities would like so to systematize and stabilize the training of our young until they approximate quite closely to the workers and warriors of an ant hill. Fortunately, such plans always fail. The urge of youth to adapt itself to the ever-changing conditions of our modern life, with its continually increasing gifts from science that modify not only our thoughts but our every-day existence, prevent such a catastrophe.

Desirable Relations between Professor and Student

A professor cannot but regard it as a very high honor when an advanced student elects to work in his department. I know of no academic or other distinction that may come to a teacher and investigator than can surpass this, as a reward for years of effort to perfect himself in his science and to advance knowledge. The professor is in duty bound to treat such students

* Address written for the dedication exercises of the Francis P. Garvan Chair of Chemical Education at The Johns Hopkins University, October 11, 1929.

as equals in every respect. Consideration based on age, academic position, honors won, and discoveries made are not present in the mind of the older man as he extends a welcoming hand to the younger. As one of Shakespeare's characters says of himself to another: "An older soldier not a better." When and if in the course of time, by virtue of superior endowment, the younger man turns out to be the better soldier, a field marshal perhaps in the army of science, the older soldier will thank the gods for his one-time association with a genius. Nothing will give your professors in the departments of physics, physical chemistry, and chemistry in general such high moments of pleasure as to find that from among your number there is to come another Rowland, a Willard Gibbs, a van't Hoff, or an Emil Fischer.

Leaving young men of real genius aside, as beings that appear at rare intervals only and taking the superior student alone into consideration, we may discuss some points that arise in the relations that should exist between such students and their professors. First, as I have already intimated, the young man should never for a single instant be made to feel that he is not in every way inherently as able a man as his chief or that when the day comes he will not be capable of taking over the chief's post, if he should care to accept it. This is no attitude of flattery on the part of the older man. It is the natural attitude of the true teacher toward his disciples; he is not puffed up with vain pride and is well aware of the great advantages that lie on the side of youth. It has been my good fortune to have known in my time a considerable number of distinguished teachers and investigators, and almost without exception, they were men who treated the younger men who worked with them as their intellectual equals in every way. One of my teachers approximated as nearly as it is possible for a human being to do to the ideal philosopher and true lover of learning as described by Socrates in the sixth book of the Republic (Jowett's translation), "A man whose desires are drawn toward knowledge in every form and who is therefore absorbed in the pleasures of the soul—one who is harmoniously constituted, who is not covetous or mean, or a boaster or a coward and can never therefore be unjust or hard in his dealings—he has no secret corner of meanness and is a searcher after and lover of the truth in all things." Carl Ludwig, the distinguished professor of physiology in the University of Leipzig, came the nearest to a possession of these qualities of all of the teachers of my younger days.

Secondly, it is best that any influence that may emanate from the older man should be exerted indirectly and if I may say so quite unconsciously on his part. Nothing is more irritating to all of us than constant admonition and exhortation. It has been a characteristic of all ages that reformers of all kinds, men with high ideals to be sure, have been impelled to bring others to their own point of view by drastic laws and forcible measures.

The teacher and investigator has many opportunities to give his students direct and detailed instruction in matters of technic and in ways of approaching a problem that are the natural outcome of his longer experience in research work, but when it comes to a question of improving a young man's critical ability or conscientiousness, of strengthening a tendency on his part to give up too easily and to despair in the face of unforeseen difficulties, or if one notes a tendency on his part to let preconceived notions have the right of way over unwelcome findings of fact, then also a reform, if it is possible to effect it, can best be brought about in an indirect manner. This may consist in tactfully calling attention at an opportune time to some of the numerous cases in the literature of science where one or more of these quite human failings have marred even a great man's work in his early days. A case in point is the story of three papers written by H. Davy at the age of twenty-one, shortly after he became the assistant of Dr. Beddoes, the enthusiastic but uncritical head of a pneumatic institute at Bristol. I have not yet had an opportunity to read these papers, but Ostwald tells us in his essay on Davy that they appeared in 1799 in the first volume of Dr. Beddoes' "Contributions to Physical and Medical Knowledge, principally from the West of England." The papers were entitled: "On Heat, Light and the Combinations of Light; On Phos-Oxygen or Oxygen and Its Combinations; On the Theory of Respiration." Five years before the publication of these papers, at the early age of seventeen, Davy had already made his famous experiment in favor of the theory of the "immateriality" of heat, by rubbing together two pieces of ice in a vacuum until they were partly melted. According to Ostwald, however, the three papers of 1799 "contain nothing that was afterwards incorporated into science; they are a compilation of the wildest speculations supported only by a slender and fragmentary knowledge of the science of the day—while heat was regarded by him as a mode of motion, light was considered to be a material substance whose weight he believed he had determined (later letter) . . . In later years Davy bitterly regretted the publication of the three papers."

Then there is a second way in which indirect influence is exerted and that lies in this that young men, fortunately, learn from each other. In any given laboratory where there are a number of workers, the individual investigator will be sure to find one (or more) among his contemporaries or instructors who possesses in higher degree this or that mental or moral quality in regard to which he himself is relatively deficient and from them he unconsciously acquires higher standards.

We come back then to what has been known to wise men from the earliest times that the best instruction is by example. The reasons for this are not far to seek. It is not forced upon one. Then, too, the method tends less than any other to arouse the natural spirit of opposition and pugnacity, present in a greater or lesser degree in all of us. The method of

teaching by example is also the only one that is applicable throughout the whole of life. The oldest among us as well as the youngest can avail himself of this, the greatest of all pedagogical methods. In matters of health as in ethical matters that bear on our relations to others, young men in the "slipperiest years of life, those from seventeen to twenty-five" may well heed a passage to be found in Roger Ascham's Scholemaster (1570). "Erasmus, the honour of learning of all our time, saide wiselie that experience is the common scholehouse of foles, and ill men: Men of witte and honestie, be otherwise instructed. For there be, that kept them out of fier and yet was never burned . . ." with other examples of what "experience" may lead to.

The Reaction of the Professor to Suggestions of the Student

There is one point in which older scholars in every department of knowledge often make what is perhaps the most serious blunder that can be made in their relations with their juniors. What I have in mind consists in underrating or even refusing entirely to accept the suggestions of a student. The history of science shows how many outstanding discoveries have been made by young men in their twenties, say. You will say that these discoveries were made by the *élite* of our race. True, the most of us are not men of genius, but we must nevertheless do our small part in extending knowledge in points of detail, or in perfecting certain fields of science so that they may serve the everyday needs of mankind. And in this connection I may be permitted to say that I do not fully approve of the distinction so often made between pure and applied science. I prefer the definition of Pasteur who objected to this classification. Said he, as I recall it, there is only *science*, but in the one case this is applied to the solution of problems that concern human needs, that is to say they have a utilitarian aspect; in the other case, science is used to discover something as yet quite unknown. Very naturally in this last instance the imagination and the mental powers of investigators are not in the least confined and it is here that they have scored their greatest triumphs. It is often quite difficult even in the case of the leaders in the natural sciences to state how much their work comes under the classification of applied science and how much under that of so-called pure science. Often a discovery that is classed under the heading applied science serves in its turn to open up new fields of knowledge.

But to return to my point about the particular misfortune that occasionally arises when the professor fails to adopt a brilliant suggestion of his pupil. There are some striking instances of this failure to be found in the literature of science, but it is likely that most of them have been suppressed for quite obvious reasons. A number of such instances, have, however, occurred in recent years and I should like to relate two of them. Two

years ago I delivered a lecture before an audience of chemists and biologists in the university of one of our large cities. My lecture dealt with the discoveries made in the past fifty years or so in a new department of biological and medical science—that of the so-called endocrine organs and the diseases referable to them—a field in which chemistry has been of inestimable service. One of my topics dealt with recent discoveries in relation to the familiar disease called diabetes mellitus, known to the layman merely as diabetes, as he is little interested in a very different malady called diabetes insipidus. At this time a young investigator, Banting, had just succeeded in further verifying an earlier hypothesis as to the cause of the disease and with the assistance of his young associates had prepared an extract from the pancreas of beeves and hogs that revolutionized our hitherto powerless medical practice in relation to the disease. Administration of the extract to diabetics acts in a manner that is truly marvelous, and annually restores many thousands of them to a normal state of health as long as they continue to take the extract. Now a few years before Banting's discovery a young man had taken up this very problem on the advice of the professor of physiology in the unnamed university where I was giving my lecture. The results obtained by this young man, whom we may call Dr. Y, were so good that he is always referred to in company with several other American and European investigators of the past twenty years as among those who "almost hit it" and writers on the subject have wondered why he gave up the research. Very naturally in my lecture I had discussed the results obtained by Dr. Y and after the lecture I happened to sit next to the Professor who had given the problem to Dr. Y and being desirous of learning why the very promising results had not been followed out, I said, "Professor X, why did not young Dr. Y continue the research, and follow up and clinch his striking observations?" To which Professor X replied: "Abel, that was all my fault, I told him there was nothing in it."

The second instance concerns Banting and his professor, the well-known physiologist J. J. R. Macleod, who at that time occupied the chair of physiology at Toronto and who is now at the University of Aberdeen. In his Cameron Lecture delivered before the University of Edinburgh (*Edinburgh Medical Journal*, **1929**) Banting relates how the reading of a certain paper that pointed out the analogy between the degenerative changes which follow ligation of the pancreatic duct in animals and the blockage of the duct by gallstones, caused such a ferment in his mind that he was unable to sleep. At two o'clock in the morning an idea had crystallized in a form that would lend itself to experimentation. He thereupon entered the following words in his notebook, "Ligate pancreatic ducts of dogs. Wait six to eight weeks for degeneration. Remove the residue and extract." The following morning he consulted a number of professors in his own university as to the possibilities of obtaining facilities for experi-

mental work. As new medical buildings were in the course of erection (London, Ontario) he was advised to consult Professor J. J. R. Macleod of the University of Toronto, an eminent investigator and authority in the field of carbohydrate metabolism. Banting says: "I shall never forget that first interview with Professor Macleod. Evidently my case was poorly presented, because at the end of the interview the Professor asked me what I hoped to accomplish when the best-trained physiologists had not succeeded in establishing or proving that there was an internal secretion of the pancreas. My request was that I should be given ten dogs, an assistant for eight weeks, and facilities for doing blood- and urine-sugar estimations." Surgical confrères in Toronto were also consulted and four months later active work was begun in Professor Macleod's laboratory, from which it may be inferred that the Professor's skepticism in respect to Banting's ability to carry out the projected research was neither deep-seated nor permanent.

In this connection the late Professor Starling has said ("Discovery and Research," *Nature*, April 26, **1924**)—"The preparation of insulin by Banting and Best, an admirable piece of work, is but the last step of an arduous journey, in which hundreds of workers have taken part. In the history of insulin the greatest achievement was probably that of Minkowski when he showed that diabetes could be produced by extirpation of the pancreas. . . . . The Medical Research Council has no need to concern itself with 'discoveries.' All it has to do is to ensure that the growing tree of knowledge is dug round and pruned, dunged, and watered. The fruit will come in due season, and will fall to the lot of some one who may or may not have been assiduous in the labor of cultivation." To which I would add that the lap into which the ripe fruit finally falls generally has a very good head atop of it.

Two instances of the same character occurred in my own relations in my younger days with revered teachers in Europe, but these concerned problems of minor importance as compared with that under consideration so that I shall not speak of them further than to say that in both instances I was able to carry the researches to the conclusion at which I had hoped to arrive despite the skepticism of older and wiser heads. Such instances have always made me advise young men of ability to listen to what older men say, but to preserve their own independence of thought when they are confident that they themselves rather than the professor are on the right road.

The Reaction of the Student to Suggestions of the Professor

Thus far I have been speaking of the mistakes that professors may make in their association with younger men and it may have appeared to you that these mistakes are made because of greater age and an inhospitality to

new ideas on their part. Advanced students and young instructors are also however by no means immune against such errors. Let us consider the reverse of the above statements—a case in which the professor himself propounds new and novel ideas to a group of his younger men. You will perhaps permit me in this connection to give one experience of my own, much as I dislike to speak in the first person. I recall an instance in which I had evolved a plan for passing the blood of a living animal through an apparatus which has been called an "artificial kidney" or, more correctly speaking, a vividiffusion apparatus. Utilizing the principles of diffusion, with the circulating blood made non-coagulable, such an apparatus would enable us to accumulate and separate substances that are present in minute amount only in the blood. It might possibly enable us also in cases of fatal diseases of the kidney to prolong life for a time at least by removing metabolic poisonous products from the blood. On presenting the proposition I encountered the same skepticism and met with the same criticisms that might have been offered by a group of professors. Every imaginable obstacle to ultimate success was thought of by one member or another of the group. I need not say that all of the objections were welcomed by me and that I tried to meet them as best I could. The consensus of opinion was that the scheme was impracticable. As I recall it, however, two of the young men were less sure and thought that the plan might be made to work. With the help of a glass blower I devised a compact form of apparatus fitted out with suitable dialyzing tubes that could be tried out on a rabbit. The very first experiments on this small animal showed that the scheme was feasible and later experiments on larger animals, such as dogs, were still more successful. After this demonstration all doubts were dispelled and thereupon a number of my younger associates joined me in a series of researches in this field. One of the young men who was most hopeful of a good outcome from the very beginning afterward went with me to London and Groningen, Holland, at both of which places we gave demonstrations on living animals before scientific congresses. After the London demonstration one of the most distinguished of the English physiologists of the day, a man at that time about 60 years of age, said to me, "Abel, I had this same idea some years ago but gave it up because I thought the scheme was impracticable and could never be made to work." So you see that in their attitude toward new ideas the older and younger investigators do not differ so widely. The young men, however, with a smaller store of personal experience and perhaps a less acute realization of all of the possibilities that may be encountered in such a case are more willing to take a risk. I could cite other instances in which young men have been just about as conservative as the oldest among us. We are dealing, therefore, not entirely with a matter of age or of inhospitality to new ideas but rather with a fundamental question of psychology. We can-

not foresee all of the difficulties that may be encountered when one enters upon a new line of work. It is a curious thing in the history of science that many men, and even great ones among them, have opened up new fields which, on the basis of the original proposals and schemes first outlined by them, went counter to existing knowledge and from many points of view were quite illogical and foolish in the opinion of men of wider experience. As work proceeded, however, new circumstances arose which these daring individuals with open eyes and "a prepared mind" utilized to advantage and finally a discovery eventuated which a less daring, more experienced, and in fact a more logical individual would never have attempted. Here lies one of the secrets why young men with little previous experience but with the imaginative faculty highly developed and endowed with the qualities of dogged persistence, undaunted courage, and with the readiness to accept a new turn in the experiments, so often make very great discoveries quite early in life.

It may happen that a young man who is working either on a problem of his own or one that has been suggested by his professor finally finds himself in a troubled state of mind and of indecision, more especially at times of overwork and strain. Are the results really such as they appear to be? He repeats experiments, checks up his weighings, and still his worried state of mind persists. I once found myself in this state of mind when I was working on a problem in the laboratory of the well-known chemist and biochemist, Marcellus v. Nencki, who held the chair of biochemistry in the University of Bern in the eighties of the past century. This state of mind is well known to all workers, and I may say this is not the only time in my life when I have been troubled in this way. Finally I went to v. Nencki. After listening to my story and noting my state of mind, he said, "See here, Abel, it is your business to make up your own mind and to arrive at some sort of a conclusion. If you are confident that you are right, it is your business to convince me and then other scientists." This advice had a steadying influence on me. Naturally, we ourselves are the ones most easily convinced and here is where stern self-criticism and freedom from preconceived ideas must be summoned to our aid.

Reading and Studying

I come now to another point that arises in our relations with young men and that touches the matter of reading and study. The period of youth with its unbounded energy and its power of uptake is especially the time for acquisition of knowledge, the laying of a broad foundation, and hence of wide and extensive reading. I have observed that there are two ways of studying and reading. There is a class of young men of superior endowment and *early* maturity who read from their earliest years in the following manner and it is from this class, I believe, that most of our great investi-

gators are recruited. Many of them begin to experiment in boyhood. They have so many ideas, so much curiosity in regard to the make-up of the world about them, so many plans to accomplish something worthwhile that the greater part of what is read and studied is examined and digested with reference to the ideas that are fermenting in their cranium. As far as I know this method of study has been that practiced by the great investigators of the past, many of whom in their boyhood were the despair of their classical and other instructors who failed entirely to note that they were dealing with gifted youths whose minds were otherwise occupied and who, in their own way, were laying the foundations of future greatness.

The other and very different manner of study and reading is one practiced by those who are often men of great mental capacity and in whom the analytical and critical ability is highly developed, but who are by nature conservatives rather than rebels and innovators. Men of this type are the most learned and the best of students. They are in the majority but sometimes they remain all their lives examples of "full men" only. The distinction that I have made is not absolute. The great majority of our scholars and scientific men are a composite of the two types.

It is inadvisable, I think, for an advanced student to read too much in a *particular* field of research before he begins a piece of work in that field unless indeed he belongs to the first class and takes up a problem on which he has long meditated and has already evolved a novel and daring method of approach. A man without a plan of his own may be so completely filled with what he has absorbed that he is quite unconsciously under the mental dominance of his predecessors even when, as Ostwald remarks, he goes so far as to take the entirely opposite view from that of his predecessors; whereas real success may lie somewhere between the two extremes.

A tale used to be told in my time of study abroad about the distinguished Bunsen to the effect that he sometimes began an investigation without having done any reading in the previous history of the subject. Later, after he had made a number of discoveries he began to look up the literature and then crossed off the discoveries that others had made before him and, being Bunsen, he always had something new and significant left over.

What I have said about the desirability of getting early into the habit of formulating plans for research leads me very naturally to suggest that we must try to get time for reflection. Too many of us tend to work all day in our laboratories with our hands and feet and not enough with the grey matter of our brains. It is an old saying ever since Archimedes solved the problem of specific gravity in his bath tub and gave the world what Whitehead calls its first great example of mathematical physics, that discoveries are not made in the laboratories but in the bath tub, or during an afternoon or evening walk as in the case of Helmholtz, or in the watches of the night when the puzzled brain will not quiet down as has been the experience of

so many investigators. When discoveries are made off-hand, as it were, in the laboratory, it is often because "the prepared mind" has not let some significant occurrences pass by unnoticed and unrecorded.

Mistakes

Then there is the matter of mistakes. Let no young man be discouraged when he finds himself making mistakes. Of course, one must avoid getting them into print! You will find that your predecessors, no matter how great their achievements, all have, like Liebig, "their cupboard of mistakes" and the record of great opportunities that were allowed to slip by. "It is related by Schutzenberger on the authority of Stas that some years before the isolation of bromine by Balard, a bottle of nearly pure bromine was sent to Liebig by a German company, manufacturers of ordinary table salt, with the request that he would examine it. Somewhat carelessly Liebig tested the product and assumed that it was chloride of iodine. Then he put away the bottle probably with the intention of investigating its contents more closely at some future time. When he heard of Balard's discovery he realized what he had missed. Schutzenberger says he kept the bottle in a special cupboard labeled "*Cupboard of Mistakes*" and would sometimes show it to his friends as an example of the danger of preconceived ideas and of arriving at a conclusion too promptly." (Wootton's "Chronicles of Pharmacy," **1,** 339).

Journal Clubs

Reading and filling our minds too full of a subject before making trial of our own powers in a given field induces me to say a final word about Journal Clubs. I refer here not to clubs or seminars in which the members of a department each in turn gives his own findings with an account of related researches, but to bi-weekly or monthly meetings in which members of the staff and advanced students give a complete resumé of all of the recent work in relation to this or that problem. It is often stated that a performance of this kind is of great value to a young man as it teaches him how to present a subject properly to an audience. As far as the listener is concerned it is really only an example of instruction by lectures. These, to be sure, have their place in our scheme of education. A few years ago I heard a very distinguished visiting European investigator in the field of hydrodynamics—I do not recall his name at the moment—say that if he were given the powers of an autocrat over our American universities he would see that no professor would be permitted to give more than one lecture a week throughout the year.

I have myself reached the conclusion that the best kind of Journal Club is the noon-hour lunch table. Here are assembled together for a simple midday meal, the entire staff from student assistants to the young investi-

gators at work in the laboratory and the professors in charge. The plan may not be feasible in very large institutes.

The method is in use in some of the laboratories of The Johns Hopkins Medical School but there also are found here old-time Journal Clubs or modifications of them in the way of young men's societies, one or another of whose members reports progress in his own field of research. I have found the lunch hour under the circumstances cited to be the most delightful hour or half-hour of the day. It has the great advantage that during this informal period all of the workers come into daily contact with their instructors, something that might not otherwise be possible. Naturally, the talk is largely shop talk. The difficulties encountered in this or that investigation are discussed freely. The younger men with their greater leisure for omnivorous reading make good suggestions and often call attention to a piece of work that has a distinct bearing on the subject under consideration. Sometimes we make the world over to our liking and then come down to earth and go back to our work. Best of all, every one, including the professor, soon learns not to take himself or life too seriously. Research work involves hard and continuous thinking and inevitable mental strain and it is unfortunate if we cannot learn to carry it on with a certain amount of poise, if not exactly happiness, and to retain a sense of humor, all of which are essential if one wishes to continue to work throughout a life-time at the fascinating game of research, and surely none of these attitudes of mind are incompatible with hard work. In spite of the saying that the only wise men are the pessimists, I still think it would be best if we could turn out our researches and write them up in somewhat of the gay spirit in which the bird sings its song. Controversies and discouragements naturally arise in the life of the investigator; some of his work will most likely fail of acceptance, again he may have to wait many years before it is found that he was, after all, right. The superior student will be sure to meet with such experiences in life, the more so, the greater his achievements and the more prolific he turns out to be. Tenacity of purpose, continued labor directed by the harmoniously constituted mind of Plato's philosopher in so far as this state can be attained, will enable one, if endowed with the other mental attributes named above, to win out in the end.

Beryl Crystals Found in Maine Quarry. Enormous crystals of beryl, 12 to 14 feet long and two or three feet in diameter, have lately been discovered near Albany, Me., Prof. W. B. Scott of Princeton University reported to the National Academy of Sciences meeting recently at Princeton. Beryl is usually rated as a semi-precious stone, and crystals of this size are simply monumental. Prof. Scott wishes to find some way by which this group can be saved from destruction and permanently preserved as it now stands.—*Science Service*

CHEMICAL WARFARE. III. WEAPONS, TACTICS, AND PROTECTION

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The application of chemical agents in modern warfare has brought about intensive study of the three fundamental subjects—weapons, tactics, and protection—from an entirely new point of view. The practical effect on the three is different in each case. Thus it has caused existing weapons of warfare to be modified, and has brought about the development of new weapons, the sole purpose of which is the projection of such agents. In the second case no change has been found to be produced. The fundamental tactics of warfare apply to the principles of chemical warfare just as to other means of accomplishing the same end, namely, the defeat and subjugation of the enemy. In the third case an entirely new feature of warfare has been found necessary. Whereas before the World War protection consisted merely of providing fortresses and trenches for mass personnel, now it must include individual protection as well, and in such form that it may be instantly available at all times and under all circumstances.

In the present paper we shall be concerned with a brief study of the effect of the introduction of chemical agents upon the three subjects mentioned. We shall consider them in the order listed in the title of this paper.

Weapons

From the standpoint of the number of chemical shells fired, the cannon ranks supreme. To this must be added the ever-increasing use of airplane bombs and spraying devices, the full utility of which is still a problem for the future to solve. However, there are a number of very important tactical conditions under which the cannon and the airplane are not available, or which, under such circumstances, are not effective. To meet this demand there have been developed several types of chemical projectors, among which are chemical hand and rifle grenades, candles, cylinders, Stokes mortar, and Livens projector.

(1) **Artillery Shell.**—Chemical agents find wide applicability in artillery fire in practically all cases where such fire is desirable. The agents with which such shells are filled are, in general, as follows: bromobenzylcyanide, chloroacetophenone, chloropicrin, phosgene, and mustard.

Practically every type of artillery gun is available for the use of chemical agents, and no revolutionary changes in the construction of such shells has been found necessary. The 75-mm. gun is effective between the limits of 2000–8000 yards. The 125 mm. howitzer has an effective range between 5000–11,000 yards, and the 155 mm. gun between 8000–17,000 yards.

The artillery employs chemical agents for barrage, destruction, neutralization, demoralization, counterbattery, harassing, etc. The effect of an agent depends upon the concentration in air maintained upon the target. Since artillery shells are fired in sequence, the shells do not burst simul-

taneously, each burst moving off with the wind, growing in size and diluting in content. Accordingly, in order to obtain an effective concentration it is necessary to deliver a large quantity of shells before the first have become ineffective. Owing to the great rapidity of fire maintained by modern artillery this condition may readily be realized.

(2) **Aircraft Bombs and Devices.**—Since little or no use was made of chemical agents by the Air Service during the World War, the very great possibilities inherent in such use have not been fully appreciated. Marked developments in both chemical warfare and the Air Service indicates a leading rôle for these two in the future.

Chemical agents may be carried in every type of aircraft bomb from the half-pound incendiary type to the four thousand-pound destructive type. In general, the small type bomb is preferable, which, carried in large quantities, may be scattered over large areas. This type is carried in a large container which when released automatically opens and scatters the bombs over fairly large territory. Special spraying devices have been employed on aircraft which furnish a continuous supply of agent to the target or area to be sprayed.

Bombs weighing from twenty-five pounds up are carried on the lower wings of the smaller aircraft, or in the bombing compartments of the larger craft. Objectives of this arm of the service include concentration camps, supply depots, transportation centers, manufacturing plants, and centers of personnel. The agents employed vary with the purpose for which they are intended, and include practically the entire range of chemical agents. This service is particularly effective in screening, harassing, demoralizing, and destroying material.

(3) **Special Chemical Weapons.**—Under this heading is included all those devices which have been developed, or modified, for use of personnel exclusively employing chemical agents. These weapons are of the greatest importance and owing to their flexibility are widely used. Their use demands a trained personnel and such weapons are the special equipment of chemical warfare troops.

(*a*) *Cylinders.*—The first gas attacks of the late war were delivered by means of cylinders. The obvious advantage of such weapons consists in the fact that a very high concentration can be delivered upon a wide front. The clouds so produced were transported by the wind over targets, completely enveloping them in a continuous pervading blanket of agent, flowing into dugouts, trenches, and shelters, and penetrating for considerable depth into the enemy territory. Naturally, such attacks are utterly dependent upon the prevailing winds, and the cylinders as first employed were so heavy and bulky that their use gradually declined. Now, however, light, one-man, portable cylinders of high efficiency have been developed, and their use in the future is certain. Cylinders are generally used with non-

persistent agents for casualty agents alone, and their greatest use will be found in stabilized warfare.

The cylinder is a drawn steel tank and is discharged by means of a Y-valve and eduction tube, the latter being a $^3/_8$-inch iron pipe screwed into the valve and terminating close to the bottom of the cylinder. The cylinder contains about thirty pounds of chemical agent. The high vapor pressure of the liquefied gas in the cylinder builds up considerable pressure, and when the valve is opened this pressure forces the liquid downward, and it seeks outlet through the eduction tube. In the diminished atmospheric pressure the liquid immediately vaporizes. The most efficient filler for cylinders is phosgene with about eight per cent liquid carbon dioxide to facilitate expelling the mixture.

(*b*) *Candles.*—The candles are classified as smoke, toxic, or lachrymatory, according to the agent with which they are filled. They were developed to meet the need of a portable smoke producer to be utilized by individual troops for screening purposes. They are particularly valuable in screening flanks, river crossing, etc. They may be employed to screen, disguise, simulate attack, or to divert attention from an important position or movement. Emplacements of candles, fired electrically, have many of the advantages of cylinder attacks, without their disadvantages. Since these weapons are similar in all respects, differing only in filler, only one type need be described.

The diphenylaminechloroarsine toxic smoke candle consists of two compartments of sheet steel, placed one above the other, and bolted with asbestos packing. The lower compartment contains about three pounds of smokeless powder cake, as fuel, upon which there is mounted a match-head and phosphorus-coated wire scratcher as ignition device. A flue provides communication between the two compartments. The upper compartment contains a two-pound cake of the agent, above which there is a deflector, the purpose of which is to cause sublimation of the chemical without its decomposition by heat. This is accomplished by passing the hot gases from the burning powder into the upper compartment and across the surface of the diphenylaminechloroarsine. The result is the formation of very minute solid particles, thus forming a smoke. The completed candle weighs no more than ten pounds, burns for about two minutes and the cloud produced has obscuring power and an immediate toxic effect. It causes sneezing, coughing, and vomiting, followed by physical and mental depression. Such candles are primarily used for harassing; for penetrating and for slowing up the masking process, thus allowing a more toxic gas to take effect.

(*c*) *Grenades.*—A chemical grenade is a missile filled with gas, smoke or incendiary material, thrown by hand or fired by a rifle, and dispersed by ignition or by an exploding device. They are intended for use by ground

A White Phosphorus Bomb Burst

troops to cause casualties, to screen movements or to blind small targets; to harass and to destroy materials. Their greatest and most general use is reached in trench or stabilized warfare, although they find some application in movements involving both offense and defense. Both types of grenades are barrel-shaped containers of drawn sheet steel containing the exploding device and the filling of chemical material. The hand grenades have a range of thirty-five yards and are used only against close targets such as in clearing shelters and dugouts, to screen and blind, or to demoralize preparatory to an attack. The rifle grenade has a range from 175–275 yards and is used against definite local targets, particularly those that appear during a rapid advance. Both types of grenades are divided into two classes—the exploding type and the burning type. A description of one of each will not be amiss.

Let us take the white phosphorus exploding rifle grenade, mounted on a steel rod which is inserted into the muzzle of the rifle and fired by means of a special blank cartridge. The type is the five-second time fuse, exploding. It is ignited by a shear-wire inertia-pellet mechanism and time fuse assembly with a commercial detonator. It is filled with about nine ounces of white phosphorus and produces a pure white, dense, slightly acid, non-toxic smoke of great obscuring power. The burst is accompanied by a shower of burning particles which continues for about two minutes. The diameter of such a cloud is about fifteen yards. It is used to screen local movements, to blind small targets, to inflict casualties and to set fire to inflammable objects. It may be used alone or in combination with gas.

The chloroacetophenone burning hand grenade is the five-second time fuse burning type. It is ignited by a Bouchon and fuse assembly with a fraction of a gram of black powder flash, and contains a starter mixture of meal powder. The filling is about 100 grams of a mixture containing about twenty-seven per cent chloroacetophenone, seventy per cent smokeless powder and the remainder magnesium oxide. It produces a bluish gray to colorless cloud, immediately irritating and incapacitating, and causes copious lachrymation. It is for all practical purposes non-toxic, and has but little obscuring effect. It burns for about five minutes and finds its chief use in clearing dugouts and shelters, forcing masking, and in harassing. It may be employed combined with smoke.

(*d*) *Stokes Mortar.*—The 4-inch Stokes mortar, developed by the British and later adopted by all belligerents, is the exclusive weapon of chemical warfare troops in support of infantry. The mortar is a muzzle loading high-angle fire weapon consisting of a barrel, bipod, and base plate. It is loaded and fired by simply dropping a complete round into the muzzle, a percussion cap in the base of the shell coming in contact with a stationary firing pin in the bottom of the barrel. It can fire up to twenty rounds per minute, although the effective rapidity of fire is ten rounds per minute. Its

THE TEAR GAS HAND GRENADE FOR TRAINING PURPOSES

1. Body. 2. Thimble. 3. Bouchon. 4. Assembled Grenade.

high angle of fire permits its operation from cover and its range, from 200 to 1200 yards, makes it a very flexible weapon. It is sufficiently accurate to be employed upon definite targets, and its assemblage makes it about as mobile as a machine gun with equipment. This mortar is suitable for firing any type of chemical agent and for the production of almost any tactical effect. Its chief disadvantage is the weight of ammunition required for each gun in connection with the great rapidity of fire. However, this, in connection with the relatively large amount of agent per shell, makes possible the sudden delivery of high concentrations on a target—especially desirable conditions for chemical warfare.

The mortar and its assemblage consists of barrel, base plate, bipod, and tools, the total weight being about 265 pounds. The barrel is a seamless drawn steel tube with a smooth bore 4.2 inches in diameter. It is something over four feet long and varies in thickness from base to muzzle. The base cap is of steel, its rounded end forming a ball and socket joint with the base plate. The bipod furnishes support for the mortar when in position and includes a two-legged trunnion standard with elevating and transversing mechanism. The shell for use with this weapon contains the burster, fuse, and propellant charge. The shell casing is a cylindrical tube made of steel. The burster contains tetryl in a brass tube, a commercial detonator containing fulminate of mercury, and a felt washer. The fuse is an impact or percussion fuse, and the propellant charge consists of 12-gage cartridges with powder rings. These latter contain grains of smokeless powder and their number used for a particular shell determines the range. The filling varies from about seven pounds of phosgene to about ten pounds of white phosphorus. The completed shell, fused, weighs approximately twenty-five pounds. Chemical mortars are fired in batteries varying in number from two or three to fifteen or more.

(*e*) *Livens Projector.*—This is another weapon strictly applicable to chemical troops. It was developed by the British and universally adopted shortly after its introduction. The projector consists of a steel tube of uniform cross-section, with an internal diameter of about eight inches. It is set against a steel plate embedded at an angle in a trench previously prepared therefor. The charge is contained in a shell resembling nothing so much as an ordinary lard bucket. The completed charge weighs approximately sixty pounds of which half is the chemical agent.

These weapons are fired by electricity, the lead wires from each projector coming out of the muzzle and joining to a single lead which makes contact with a blasting machine. One of these machines can operate from twenty to thirty projectors. Ordinarily a battery of 100 to 150 Livens projectors are discharged at once. The British fired nearly 2500 at one time in an attack upon Lens. One of the chief disadvantages of this weapon is the great amount of labor in digging them in. The weapon can

be used for firing only one charge after which it must be salvaged, rearranged and dug in again if it is to be used. These weapons throw gas cylinders into the ranks of the enemy where they explode, thus releasing a heavy cloud of gas at a time and point where it was totally unexpected. It thus involves the advantages of the cloud attack as compared with artillery shell, and without the dependence upon wind and weather characterizing cylinder attack.

Tactics

The purpose of chemical warfare is to aid ground troops in accomplishing their mission—the aim of all warfare. The contribution of chemical warfare in this respect consists in causing the enemy casualties, denying him important territory by threat of casualty, distracting his attention and annoying him, or blinding his observation. The principles involved in chemical warfare tactics are selection of targets, agents, weapons, and the application of the general principles of warfare.

(1) **Selection of Targets.**—Targets are selected because of their importance, and their threat to friendly troops, and are chosen with particular reference to their suitability as targets for chemical agents. Such targets are usually enemy personnel or areas to be denied to such personnel. The greater the number of personnel occupying the target, the greater will be the casualties produced.

Where non-persistent agents are to be employed it is necessary that the target be occupied by the enemy at the time of projection. On the other hand, persistent agents may be employed on areas likely to be occupied by the enemy within the time of effectiveness of the agent. Targets primarily fitted for harassing are those such as headquarters, lines of communication, working parties, and reserves. In screening operations the target is selected from those that afford the enemy the greatest value in the direction of operations. Targets suitable for incendiary or destructive agents are supply points, temporary shelters, etc. Persistent agents are employed in denying areas and in counterbattery and retaliatory fire.

(2) **Selection of Agents.**—The governing factor in the selection of agents is the purpose for which they are to be used. Thus, phosgene is employed on definite targets, for casualty effect, using weapons delivering large quantities of agents in a short space of time. Owing to its nature it may be selected for employment just prior to an attack and in conjunction with smoke if desired.

Mustard may be used for casualty effect, for denying areas, for harassing, counterbattery work, and for lowering the morale. It is ordinarily used in small projectiles, and may be applied over considerable periods of time. It is not to be used on a large scale just prior to attack except that it may

be so utilized on small danger points which are to be avoided in the advance.

Bromobenzylcyanide is used to harass and is fired in small projectiles. It is effective in small quantities and is persistent, consequently it is not used where it will interfere with an advance. Chloroacetophenone is used to force masking, is effective in low concentrations and is suitable for harassing over a wide area. It is used in much the same manner as bromobenzylcyanide.

White phosphorus is employed primarily for screening and blinding, and secondarily upon direct targets for the production of casualties and for lowering the morale. It may be used in preparation for the attack and during the attack. Its nature makes it a very widely used agent.

(3) **Selection of Weapons.**—The proper weapon for every tactical use is a function of the peculiar characteristics of the weapon in relation to the location, type, and size of the target, the agent to be employed, and the weather. The characteristics affecting the choice of weapons are their range, accuracy, quantity of agent capable of being delivered in given time periods, and the effect of the terrain and the atmosphere upon their use.

For example, the Livens projector is of short range and low accuracy but capable of delivering large quantities of agents in small periods of time. The cylinder is limited by the terrain and the weather conditions. It is accurate and capable of delivering the maximum amount of agent. Its range depends upon the quantity used. Candles are dependent in range upon the quantity utilized also, and otherwise resemble cylinder projections without the immobility of the latter. Grenades are of minimum range; they deliver small quantities of agent and their accuracy depends upon the individual utilizing them. The artillery is accurate and long ranged, and capable of delivering a large concentration owing to its great rapidity of fire, but is an expensive way of projecting chemical agents.

(4) **General Principles of Warfare.**—From the chemical standpoint the principle of surprise, mass, coöperation, and simplicity is of greatest importance in the employment of gas. The element of surprise decreases as the enemy training in protection and detection increases, and naturally, as this situation develops the more important this element becomes. A large part of the success of any chemical agent is directly responsible to the element of surprise, and in many cases the utter lack of this element completely neutralizes the desired effect. Surprise is obtained by secrecy of intentions and by a judicious choice of the agents available.

The principle of mass is of importance in that an agent is totally wasted if it has not been used in quantities sufficient to produce its maximum effect. Likewise, coöperation with all units, and with the plan of attack as a whole, is of major importance in the tactical use of chemical agents. Owing to the

drift of chemical clouds, the plans of adjacent units must be considered and the use of such agents coördinated therewith. Simplicity must prevail, for not only is a complicated plan far more liable to failure, but it renders coördination difficult, and increases the chances of casualties in friendly troops.

(5) **A Tactical Example.**—As an illustration of the employment of chemical agents in warfare, let us consider a possible use of such agents against an organized enemy position during the period of preparation for attack. Non-persistent casualty agents are used against strong points that are already organized and occupied in the outpost area. Against strong points being constructed in the same area, harassing agents are used, forcing unmasking and hindering the work. In the area just behind, known as the delaying area since it is here that the attack meets its first real opposition, let us assume that one very strong center of resistance has been completed. Adjoining this there is such a center projected, but not yet completed. The first center will be neutralized and denied to the enemy by the application of a large amount of persistent agent, and the adjoining center will be consistently harassed with a heavy application of harassing agent.

Having weakened the line in this manner, a resistance center adjoining the latter will be neutralized as was the first. This latter is chosen rather than some other for the reason that the line is already weak at this point due to the neutralization of the first center of resistance and the harassing of the second; accordingly, a path for the attack may be thus prepared. In the next area, known as the battle line, those centers of resistance being strengthened are made targets for harassing agents, thus interfering with the successful prosecution of the work.

Battery positions are neutralized with a persistent agent. Headquarters are bombarded with both harassing and casualty agents, while command posts are receiving a similar treatment. Lines of communication are disrupted by the application of harassing agents, and railheads and supply points are targets for harassing and incendiary agents.

In this operation the weapons most likely to be utilized would be the artillery and aircraft for positions behind the battle area, projectors for neutralizing strong points in the inner zones, while, for the continuous harassing, the mortar would be used.

This illustration of the employment of chemical agents and weapons in the tactical preparation for attack is only one possibility of the use of such agents. They may also be extensively employed in the advance, the attack, advancing the attack, reorganization or pursuit, and in organizing the captured positions. Chemical agents find extensive use in the defense of every type; passive, active, counter attacks, and in the retirement.

Protection

The first gas attack was made against personnel utterly unprotected, wholly unprepared, and powerless to combat it. Naturally, the first problem that presented itself after this attack was the matter of protection. Since the first attack the means of protection available has kept close pace with the offensive development of chemical warfare. Protection must be considered from two points of view, namely, individual and collective. In no case will either type entirely answer the requirements of both.

(1) **Individual Protection.**—The first protective device for the individual consisted of five or six layers of flannel wrapped in muslin and soaked in a solution of sodium carbonate and sodium thiosulfate. When in use they were stuffed in the mouth and nostrils and fastened by means of the wrapping. Naturally, this device was readily overcome by the use of another agent other than chlorine for which the pad was devised, but again such an attack met with an improved device. This next was the so-called black veil respirator, followed by the Pimlico helmet, and finally the mask.

The mask contained a canister in which was placed a mixture of charcoal, soda-lime, and potassium permanganate. It differs but little from that now being used. Later a felt filter pad was added to care for the penetrants which had been developed by this time. A chemical agent which resists all efforts to secure protection against it has never been found, and it is likely never will be found. At present, then, it is entirely possible to secure absolute protection against any and all chemical substances if nothing other than this is to be considered. However, other very practical and important field conditions must be considered; therefore, this absolute protection is simply the ideal toward which effort is directed, in the full knowledge, perhaps, that it can never be attained in its entity.

The battle mask should fulfil the following requirements: (1) Comfort and lightness, since it must be worn for long periods of time and must always be carried as absolutely necessary equipment. (2) Perfect fit so as to protect both the eyes and the respiratory system. (3) Unimpaired vision, since the individual vision must be limited as little as possible, both in range and clearness. (4) Freedom of movement must not be interfered with since the soldier's activity determines his efficiency. (5) It must not be fragile so as to resist a considerable amount of rough wear and tear to which military equipment is subject. (6) It must offer the minimum resistance to natural breathing. (7) The canister must be reasonably able to purify the intaken air of any and all smokes, toxic solids, and lethal vapors. (8) The canister and its contents must be mechanically strong and chemically stable, since its life must be measured in weeks and months. (9) It must be simple in construction and foolproof. (10) It must be capable of economic manufacture and in enormous volume.

The latest type of American mask embodies these features to a maximum

A SECTIONALIZED GAS MASK CANISTER

degree, although it must be realized that it, like all others to come, can never be other than a compromise. It gives the maximum protection while complying with the above requirements. Its protection is high with reference to those agents which attack the lungs, and low with those which attack the skin and other parts of the body. On account of these facts, and the additional fact that the surprise element can never be completely guarded against, absolute immunity to gas attacks can never be expected. Accordingly, such attacks will always be productive of some casualties, and it is because of this that chemical warfare is such a valuable weapon.

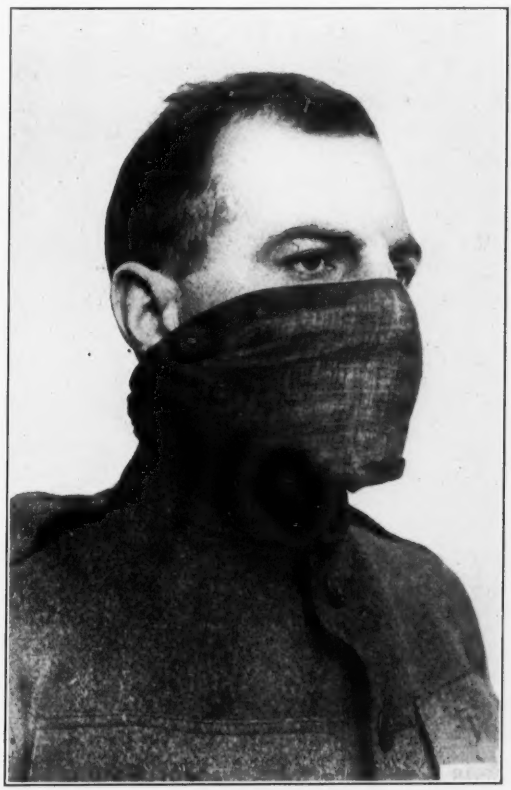
GAS MASKS DEVELOPED FOR WAR USE BY ALL COUNTRIES ENGAGED IN THE WORLD WAR

Reduction of such casualties to a minimum is the object of training and discipline in protection. The discovery, on the part of a soldier, that a mask is leaking or is otherwise defective, is most efficient in breaking down his morale. Maximum protection can be expected only when the individual is thoroughly confident of his mask, trained in its use, and conversant with its mechanism.

The principle by which the gas mask functions is the purification of the inhaled air by filtering out the smoke, toxic solid, or toxic vapor. It consists of three parts; the canister, the corrugated tube, and the facepiece. The canister is a rectangular tin box with three entrances, all at the top, for both entrance and exit of air. Rubber check valves are placed in the two openings for the entrance of air so that exhaled air may not escape through them. The exit opening is nozzle-shaped and placed between the two air entrances. The facepiece is made in sizes to snugly fit the face, the fabric being a special rubber compound, the outside of which is stockinette. Glass lenses in metal frames are inserted over the eye positions. The facepiece is held on the head by means of adjustable harness and contains a valve by means of which exhaled air escapes from the mask. The corrugated tube conducts the purified air from the canister to the facepiece, and is so constructed that it cannot collapse and shut off air should it be ben

or twisted. The completed units are carried in a satchel under the left arm and held in place by a web sling over the right shoulder and around the waist. Only the facepiece need be removed and placed over the face when the mask is in use.

The essential part of the canister is the absorbent mixture and the filter. The absorbent takes care of all toxic warfare material except the toxic smokes, or penetrants. The filter removes these by simple mechanical filtration and is constructed of material, the porosity of which is small enough to hold the finely divided toxic smokes, but not so small as to seriously interfere with breathing. The absorbent made use of, which provides protection far superior to any other that has been employed, is a mixture of soda-lime and nut shell charcoal, the former being impregnated with potassium permanganate.



THE BRITISH BLACK VEIL RESPIRATOR, THE FIRST ALLIED GAS MASK

A very high rate of absorption is one of the most important characteristics of a gas mask absorbent. The average rate at which air passes through a canister during inhalation of an exercising man is about fifty liters per minute. In the standard canister, this corresponds to an average linear velocity of about 10 cm. per second. Therefore, on the average, a given small quantity of air remains in contact with the gas absorbent for only about 0.8 second. This is certainly a very brief period in which to remove toxic material from the air. Moreover, this removal of toxic ma-

terial must be surprisingly complete. Though the concentration of gas entering the canister may be as much as 0.5%, even the momentary leakage of 0.001% (ten parts of gas per million parts of air) would cause serious and immediate discomfort, while the continued leakage of even as little as 0.0001% would have fatal results. Accordingly, it is evident that the absorbent must reduce the concentration of gas from, say, 1000 parts per million to one part per million, or less, in a time interval of 0.8 second, or less. This is accomplished with a considerable margin of safety by the present gas mask absorbent mixture. As a matter of fact, charcoal alone will reduce a concentration of 7000 parts of chloropicrin per million of air in a rapidly moving current to less than 0.5 part per million in less than 0.03 second. Thus, charcoal appears to have the maximum absorptive activity for war gases, a property which is the first requisite of such material.

Of almost equal importance is the absorptive capacity of an absorbent. It is obvious that the life of the absorbent must be measured in months, since the item of transporting and substituting new canister fillings every week or so would be entirely impractical. Moreover, only a relatively small amount of absorbent can be countenanced, for the necessity of conserving every cubic inch of space and every ounce of weight in a soldier's equipment makes it imperative to secure this large absorptive capacity with the smallest possible weight of absorbent material. This is very efficiently accomplished at present by the use of less than one pound of absorbent mixture (6.4 oz. of charcoal and 7 oz. of soda-lime). Again, the mixture must retain tenaciously the gas absorbed, and cannot be allowed to hold it in any loose combination which might give up even the minutest trace of gas when air is breathed through the canister for long periods of time. Likewise, the absorbent must be very versatile, active against any and all war gases, for it would be out of the question to provide several different types of canister fillings for general military use. There is always the possibility of meeting some new, untried gas, and the absorbent must be able to give protection under these conditions also.

Gas mask absorbents must be of sufficient mechanical strength to withstand the rough treatment in transportation and usage demanded of war supplies. It must not be subject to chemical deterioration nor to adverse weather conditions, and it must have a low resistance to breathing through it. If this latter is not accomplished, the soldier will be forced to remove the mask from time to time, and the results would be fatal. This is brought about by striking a proper balance between the porosity of the absorbent mixture, so that it is fine enough to take care of any gas and at the same time coarse enough to allow air to pass without too much obstruction. Charcoal comes surprisingly near fulfilling all of these conditions, nevertheless it alone cannot be considered a satisfactory all-round absorb-

VARIOUS GAS MASKS DEVELOPED SINCE THE WORLD WAR PERIOD

ent. In the first place it has too little capacity for certain highly volatile acid gases such as phosgene, hydrocyanic acid, etc. Secondly, certain gases are best handled by oxidation, and this cannot be accomplished by charcoal alone. Lastly, charcoal does not hold certain of the more volatile gases tenaciously enough, because the gases are held in charcoal almost entirely by physical adsorption and they, therefore, exert a certain small but definite vapor pressure when any considerable quantity of them has been taken up.

To counterbalance these deficiencies of charcoal, an alkaline oxidizing agent is mixed therewith. The material employed is granular soda-lime containing potassium permanganate. This absorbent constituent has an exceedingly high capacity for the acid gases and will oxidize all easily oxidizable gases. It constitutes a reservoir for the permanent fixation of those gases only indifferently held by charcoal. In such cases there is an actual transfer, slow but continuous, of gas from the charcoal to the soda-lime. This latter holds the gases so tenaciously that no leakage whatever occurs. Moreover, its variability with temperature and humidity is of value since it reacts more readily with increasing temperature, while charcoal decreases in activity. The net result is that there is practically no variation in the completed canister filler with weather conditions.

The absorption activity of the soda-lime is not of greatest importance, since it is mixed with a charcoal of high activity, but its absorption capacity must be extraordinarily high, since it is relied upon to hold a very large amount of toxic gas. Probably the greatest difficulty connected with the preparation of a suitable soda-lime mixture is in obtaining the requisite mechanical and chemical stability. The accepted mixture now contains hydrated lime, cement, kieselguhr, moisture, a small amount of sodium hydroxide, and a somewhat larger amount of potassium permanganate. The hydrated lime constitutes the backbone of the absorptive properties and is responsible for practically all of the gas absorption. The sole purpose of the cement is to furnish the mechanical strength necessary to withstand field conditions. It obviously interferes with the absorptive capacity of the soda-lime, but it is the least objectionable material that can be used for such purpose. The kieselguhr is added to partially overcome the decrease in porosity of soda-lime due to the inclusion of cement. It is a surprising fact, but the addition of kieselguhr does not decrease the hardness of the mixture. The function of the sodium hydroxide is to maintain the proper moisture balance, and to furnish the initial activity of absorption, thus giving the lime a chance to take care of the balance of gas in a more leisurely way. The moisture content should be kept at approximately ten per cent since it has been found that the completed canister mixture reacts most efficiently under these conditions. Provision is therefore made for the final inclusion of this amount of water. Finally, potassium permanganate is added as an efficient oxidizing agent to take care of those gases which might be introduced in warfare and against which no other protection might be provided in the present absorbent mixture. It is therefore used in the nature of an assurance of protection against new gases.

The ideal absorbent mixture must have a porosity of sufficient fineness to exhibit an extraordinary surface since it is the surface exposed which largely determines its efficiency as an absorbent. Thus in the charcoal grains most of the pores are extremely minute. From a study of the slope of the vapor pressure curve of absorbed liquids it has been calculated that the pores have, if a cylindrical form be assumed, an average diameter of about 5×10^{-7} cm. On this basis, 1 cc. of active charcoal would contain about 1000 sq. cm. of surface. Those chemical warfare agents projected as solid suspensions are not taken care of by the absorbent mixture. To care for these, a felt filter is included in the canister, through which the air must pass before being inhaled through the absorbent. The final arrangement is a marvel of efficiency and provides the maximum protection possible under field conditions.

(2) **Collective Protection.**—Under this heading is included all those devices, other than the mask—which is, of course, a most necessary feature of this also—that may be made to serve as protection for massed personnel

In general, such devices and measures as gas proof shelters, use of chemicals for destroying and neutralizing chemical warfare agents, care of material, detective and alarm devices, and special officer training are included in collective protection.

(*a*) *Gas Proof Shelters.*—Under this heading would be included all those enclosed spaces which have been so constructed as to resist the entrance of gas. They are usually huts, dugouts, or tents and serve as resting places for personnel unmasked, for wounded, for dressing stations, telephone centrals, command post, headquarters, etc. The chief principle employed in the construction of such shelters is, of course, the elimination of draughts. This demands that the shelter be easily made airtight, and that the entrance be so constructed as to refuse entrance of gas when in use. This latter is accomplished by means of a system of double doors, usually made of blankets, and so arranged as to set up an air lock condition between them. Such blankets are ordinarily treated chemically, and ventilating devices may be supplied, although such are usually omitted.

(*b*) *Destruction of Agents.*—Theoretically, all chemical agents are capable of being destroyed, or neutralized, by other chemicals. However, no one chemical is applicable in every case. Accordingly, in order to apply this principle the agent against which protection is desired must be identified and the proper chemical for its neutralization must be known. Naturally, this principle is of very limited use since it is obviously entirely impractical to attempt to combat gas with neutralizing agents on the battle field. Where certain highly persistent agents, such as mustard, have been applied to isolated areas such as command posts, headquarters, lines of communication, etc., this principle of protection may be applied.

(*c*) *Care of Material.*—Many of the chemical agents in use have a destructive effect upon metals, foods, etc. Accordingly, protection of all metallic material, food, and water supplies is absolutely essential. This protection simply consists of providing protective containers, or gas-proof storage shelters.

(*d*) *Alarm Devices.*—Under this heading are listed those devices used in spreading the alarm of a gas attack. The principles involved are the thorough training of gas sentries, their ability to recognize and identify gas, and the convenient disposition of the alarm. Such devices include horns, metallic triangles, and any other readily available noise-producing device previously decided upon, and for general alarm the usual means of communication such as phone, radio, etc.

(*e*) *Special Training.*—This would include the special instruction of designated officers in the principles of gas offense and defense. The well-trained officer knows that the most effective use of gas occurs under certain weather conditions. He would therefore be particularly observant when

such conditions are ideal, which ordinarily would involve also a study of the terrain and time effect.

The special officer is frequently able to predict an attack by means of detectable enemy activity. Preparation for gas attack involves considerable labor in preparing emplacements, bringing up the requisite supplies, etc. Again, certain attacks such as cloud or projector attacks may be detected a few seconds before reaching the line and time thereby given for alarm. The airplane is utilized here as are also certain observation posts. Since some gases may be transported in the clothing, the officer must be prepared to institute suitable protection.

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PREPARATION OF TERTIARY BUTYL CHLORIDE

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Most teachers of elementary organic chemistry have certain favorite preparations which they require of their students in the laboratory work. But all of these teachers labor under one obvious handicap, that the majority of the preparations usually require considerable time. Of course this is due to the fact that most organic reactions are "time-reactions," and is no fault of the teachers. It would seem then that any satisfactory preparation illustrating one or more important principles, and economical as regards time, might be of interest to teachers of organic chemistry. The author wishes to suggest for consideration a preparation which is required in his classes in organic chemistry. It is the preparation of tertiary butyl chloride by the action of hydrochloric acid on tertiary butyl alcohol. It illustrates two important principles: first, the synthesis of an alkyl halide from the corresponding alcohol, and second, the lability of the hydroxyl group in the tertiary alcohol as compared to that in the primary or secondary alcohols. The time required for the experiment varies from two minutes to several hours, depending upon the details required by the teacher. Briefly, if equal volumes of tertiary butyl alcohol and concentrated hydrochloric acid (sp. gr. 1.18) are shaken together, tertiary butyl chloride will separate as the top layer in the container in a short time, usually in two or three minutes. More detailed directions are as follows:

Mix 50 ml. of tertiary butyl alcohol ("practical" quality is satisfactory) with 50 ml. of concentrated hydrochloric acid (sp. gr. 1.18) in a glass-stoppered separatory funnel. Shake vigorously for several minutes, allow the layers to separate distinctly, drain off, and discard the bottom layer. To the top layer in the funnel add approximately 25 ml. of water and 1 g. of potassium carbonate. Shake, discard the aqueous layer, and empty the top layer into a flask containing about 5 g. of anhydrous potassium carbonate which is used for drying purposes. Agitate for several minutes, filter off the suspension of potassium carbonate by means of a dry filter paper and allow the filtrate, tertiary butyl chloride, to flow directly into a tared bottle. The usual yield is 30–40% of the theoretical. Of course, substitution of hydrobromic acid for the hydrochloric acid gives the tertiary butyl bromide.

Mention should be made here of the article by Davis and Murray[1] which originally suggested the above class preparation to the author.

[1] Davis and Murray, *Ind. Eng. Chem.*, **18,** 844 (1926).

Far above the conqueror of kingdoms, the destroyer of hosts by the sword or bayonet, is he whose peerless victories redden no river or whiten no plain, who rears his empires, not on the bleeding fragments of subjugated nations, but upon the realms of intellect which he has discovered and planted, and peopled with beneficient and enduring joy.—HORACE GREELEY

OSCAR LOEW*

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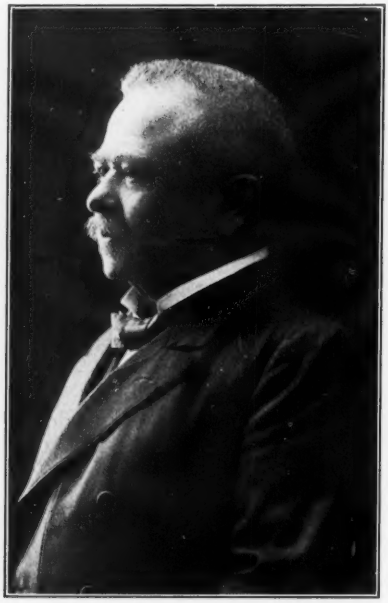
The chemists of the present generation are wont to regard Liebig and his school as mainly of historical interest, and consequently it comes as somewhat of a shock to learn that one of his students, probably the last of that noble company, is not only still living but actually engaged in practicing his profession. Oscar Loew, now in his 87th year, studied with Liebig at Munich in 1863, and at his suggestion worked on the absorptive properties of various kinds of soils. At that time, Liebig was accepting practically no laboratory students and Loew was shown this special honor largely because his father, a pharmacist, had worked in Liebig's laboratory at Giessen twenty-five years before. He had been so impressed with Liebig's powers as a teacher, that he could wish his son no greater happiness than the privilege of coming into contact with the great master. While still a child, Liebig's "Letters on Chemistry" was put into the boy's hands, and studied with diligence. All this was told to Liebig and, pleased at this well-deserved flattery, he made one of the few exceptions to his firm resolve to have no more laboratory students.



OSCAR LOEW IN JULY, 1928

In a letter to the writer of this sketch, Loew stressed the veneration carried away by each of Liebig's students and, when in later years, Loew came to America and met some of those who had been fortunate enough to have known Liebig, as Parke of the Parke, Davis and Company, and Horsford of Harvard, their conversation turned repeatedly to the influence the great master had excited upon them.

Liebig's kindness to the youth was not misplaced for his future accomplishments fully justified the valuable time and care expended on him.

Dr. Loew's scientific achievements have centered in the fields of physiological and biological chemistry. His doctorate thesis dealt with the formation of vegetable albumins and he believed that these materials were formed in the plant through the condensation of formaldehyde and am-

* This sketch has been adapted from A. Jacob, *Z. angew. Chem.*, **42**, 369 (1929).

monia. Attacking the problem as to the origin of the formaldehyde, he succeeded in preparing this compound synthetically and thus laid the foundation of its preparation on a commercial scale. He was the first to recognize the antiseptic properties of formaldehyde and it is characteristic of his mode of thought as a pure scientist that he made no effort to patent this discovery so important in medicine, seed disinfection, etc. Through condensation of formaldehyde in the presence of lime water, he was the first to prepare a synthetic sugar-like material, formose. This problem was later studied *in extenso* by Emil Fischer.

The field of enzyme catalysis also engaged his attention. He discovered the enzyme, catalase, which decomposes hydrogen peroxide. This had a practical application in the dairy industry. Decades before the work of Buchner, Loew was convinced that the activity of yeasts was not a function of the living cell, but of the enzymes produced by the yeasts. In conjunction with Emmerich, he discovered an enzyme, pyocyanase, which acts as a bacteriophage and has had some application in diphtheria.

In the field of agricultural chemistry, Loew is usually known for his work on the optimal relation of lime and magnesia as influencing plant development. This leads into the extremely complicated problem of soil chemistry and Loew was well aware of the multiple action of lime, which functions as a neutralizing agent, a plant nutrient, and as a coagulant. He is the real discoverer of the significance of the soil reaction. His interest in toxicology led to investigations relative to the stimulation of plant growth by small doses of poisons and other materials.

A rather high proportion of his life was spent beyond the boundaries of his native Germany. From 1868 to 1871 he was active as a plant physiologist in New York. After a year in Munich, he returned to America and spent four years in a long scientific expedition to Mexico, Texas, Colorado, and Southern California. From 1877 to 1893 he worked at the Botanical Institute at the University of Munich. In 1893 he went to Tokio as professor and after five years came to Washington as an "expert in physiology" in the Department of Agriculture. Returning to Tokio in 1901, he spent six years in Japan and then went to Munich. In 1913 he was made head of the biochemical division of the Botanical Institute of the University. After losing all his property, he, who by ordinary standards, would have been counted an old man, again took part in a scientific expedition, and went to Brazil. In 1926 he returned to Germany, and though more than 80, he again plunged into research. He now lives in Berlin, but he still retains his professorship in the University of Munich.

From time to time, products of his pen and laboratory still appear, and if the future may be forecast from the present he bids fair to rival the record of Chevreul. He is the "last of the Mohicans," a link between the great past and the present, and we may well pause and do him honor for what he represents and is.

CHEMICAL TRAINING FOR POWER PLANT ENGINEERS*

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It was my privilege recently to discuss corrosion with some of the engineers who control the operation of boilers generating steam at 1200 pounds pressure. In their discussion they indicated that, after several months of operation, a small amount of hydrated iron oxide had been found deposited at one point in the boilers. After first inspection it was cleaned out and did not reappear because the dissolved oxygen in the feed water was kept at zero by the Winkler test. Furthermore, the water was tested frequently with silver nitrate to detect the presence of chlorides, and the pH values were closely controlled to prevent acid corrosion or too great causticity. These men discussed intelligently the relative merits of trisodium phosphate and sulfate-soda treatment of raw water. It is indeed rare to have the maintenance division show as thorough an appreciation of the chemical problems as in this case.

This visit brought out vividly the growing importance of chemistry in the power plant, for times are changing. With the higher pressures, problems which once were troublesome are now acute, and their answer must be had by anticipating the difficulty lest there be serious consequences. Corrosion is one of the important problems, but not the sole one, affecting modern power plants. The chemistry of the metals, of fuel processing, of combustion, of refractories, and of lubrication are all significant.

Such being the case, the matter of training men to meet these technical requirements is one of no little consequence. Let us, therefore, investigate the nature of these problems, see how they are being met, and note the changes in chemical education which will best satisfy these needs.

Chemistry in the Power Plant

Some of the problems with which chemistry must deal have already been enumerated. For the sake of brevity they may be best reviewed under the headings of: (1) corrosion; (2) fuels, combustion, and furnaces; and (3) mechanical operation.

The question of corrosion is a many-sided one which can best be explained in terms of electrochemistry. Calcott and Whetzel[1] have summarized the corrosion reaction as follows:

> The tendency of corrosion of a metal by a solution depends upon (1) the potential effective for corrosion as determined by the combination of metal potential, overvoltage, and concentrations of metal and corroding ion; (2) the resistance offered by a protective

* Presented before the joint session of the Divisions of Industrial and Engineering Chemistry; Water, Sewage and Sanitation Chemistry; and Gas and Fuel Chemistry of the A. C. S. for the Symposium on "Boiler Room Chemistry" held at Columbus, Ohio, May 1, 1929.

[1] Corrosion Tests and Materials of Construction for Chemical Engineering Apparatus. Am. Inst. Chem. Engs. and D. Van Nostrand, Inc., **1923,** p. 2.

coat; and (3) depolarization reactions removing hydrogen and protective products of corrosion.

The rate of corrosion reaction varies as (1) area of metal computed from its linear dimensions, (2) rate of diffusion in corroding liquid, (3) saturation concentration of metal in corroding liquid, and (4) movement or velocity of corroding liquid.

As for the metal, steel is the usual material of which boilers are constructed. Recently alloy steels containing chromium and nickel have come into use on account of their greater resistance to oxidation and corrosion. Metal of uniform composition is used, and fabrication is done with a view to minimizing electrochemical couples. In some cases corrosion of the boiler is prevented by the application of an electromotive force, one example of which is the suspension of a zinc block in the boiler. The nature of the metal may determine the film effects, and thus affect the corrosion. For instance, adherent oxide films within the boiler or in the combustion chamber will reduce the rate of penetration, whereas those that are non-adherent may actually accelerate it. The extent of the hydrogen film which can build up before gas is evolved is also controlled by the nature of the metal. If the overvoltage created by the gas film is sufficiently great, displacement corrosion will cease.

Composition of the water has an even greater bearing on corrosion in the boiler. As a consequence boiler water treatment is known in one form or another wherever boilers are used. Water is deäerated before use because dissolved oxygen depolarizes the hydrogen film and permits corrosion to continue, and because carbon dioxide, an acidic constituent, may be economically removed in that manner. Water is treated chemically to render it slightly alkaline and also to precipitate outside of the boiler those materials which would form scale within. Under acid conditions the hydrogen overvoltage cannot be sufficiently great to prevent gas evolution and continued dissolution of the metal. Deposition of scale within the boiler permits overheating of metal with consequent oxidation as well as low rates of heat transfer. Under still more exacting conditions, or with large quantities of dissolved salts, the water is evaporated before use. These salts would otherwise accelerate corrosion by making the water a conductor and thus completing the electrochemical cell circuit, and by reacting with corroding material to produce soluble compounds in place of oxide films.

Problems in firing the boilers involve chiefly the preparation and processing of fuels, the thermodynamics of combustion and heat transfer, and the phase relations of the ash and slag compounds.

While much of the preparation of fuel, such as cleaning, crushing, and sizing, has not been associated with the power plant, there is a tendency to bring processing operations of an even more involved nature into it. Grinding processes for the preparation of pulverized coal are in common

use. Coal carbonization, or its complete gasification, although in its experimental stages, is being associated with the central station power plant. Such a scheme is intended to prepare a fuel which will be economical and clean to burn, and to produce as a by-product a marketable tar. This tar has value for the liquid fuel it contains and for the raw products of the organic chemical industry. Therefore, in fuel processing, the unit operations of chemical engineering and the organic chemistry of the hydrocarbons may be new fields for the power plant engineer.

The thermodynamics of combustion and heat transmission have been well known to power plant engineers as they have been the primary basis upon which economy depended. Heat of combustion of the fuel, equilibrium relations between the gases, and the extraction of heat by radiation and from the hot gases constitute the background of every boiler test. Less attention has been paid to rates of combustion and rates of heat absorption, but these are becoming of considerable importance for the bearing which they have on economy of design and maintenance.

The phase relations of the ash compounds and of the refractory slags constitute similar problems which are closely related to ceramic chemistry. Higher fuel bed temperatures have made necessary greater attention to the fusion point of ash. With close control a clinker results which is not too fluid for satisfactory operation of the grates, nor too dusty for use as an aggregate in cinder concrete. Thus what would otherwise be waste has a definite market value when prepared under properly controlled conditions. In powdered coal firing a new tendency is to slag the ash. It is, therefore, a real problem to be able to adapt coals of different ash composition to any one installation. Fusion points may vary, as well as the chemical action between ash and refractory. The problem from slagging refractory is less troublesome in central stations where water-cooled walls are used. A temperature gradient is established between the flame and cooling surface. The refractory is melted or the slag is built up to conform to this gradient. In smaller installations air cooling is often used to furnish the same protection. All of these fusion conditions are related to the composition of the ash and of the refractory, as well as to the operating temperature. They can be explained in terms of the phase rule system, iron oxide–alumina–silica, with due account being taken of the effect of minor constituents on the melting point.

Associated with mechanical operation is the question of lubrication which is a problem of a distinctly chemical nature. It is true that in the past lubricants have been selected on the basis of viscosity and related physical properties. While that is still significant, lubricants are now evaluated as to oiliness and power to wet metal; and in the case of cylinder and turbine oils, as to their emulsification with water. All these are properties which are associated with the chemical nature of the lubricant.

They may be recognized by the more general terms of molecular structure, surface tension, and colloidal dispersion.

A summary of these observations indicates that chemistry has a place of increasing importance for power plant engineers, and that the characteristics of the chemical field are predominantly those of physical chemistry. It is not surprising that a chemical engineer recently graduated from one of our state universities made the following remark: "So many people ask why a power house should use chemical engineering knowledge; to me the question is how do they get along on so little?"

Education in Chemistry

The technical men in control of power plant operations involving chemistry are usually mechanical engineers. Chemical engineers are occasionally to be found in the larger organizations. Consultants are employed for the special problems. In other cases technical service is offered in connection with sales. It is hardly the province of this paper to define the training of specialists, for each is a case by itself. Rather, let us consider the chemical education of that group of engineers who control the power plant.

At the present time chemistry plays an indifferent part in the training of mechanical engineers. To illustrate, H. P. Hammond[2] shows that there is a distinct continuity and interlocking of most of the courses in this curriculum. Chemistry alone is an isolated entity. This lack of connection between chemistry and mechanical engineering seems to be generally recognized. It is in part through the failure of the professional courses to recognize the value of chemistry, and also through failure of the chemist to give instruction in those fundamental fields which have a practical bearing on power plant operation.

With respect to the first of these Kirk and Heisig[3] have indicated some of the difficulties in correlating chemistry with the professional engineering curriculum:

> More criticism has been directed toward the subject matter taught in chemistry than that in physics. This is due in our opinion to two related causes. First, the course in physics is more definitely standardized than that in chemistry. Second, professional courses taught in engineering departments are based more definitely on the generally accepted standard courses in physics. The relationship between advanced professional courses in engineering and the fundamental course in chemistry is not so well established.

With respect to the second, that is, the nature and extent of chemical training for the power plant engineer, some suggestions are offered. Courses in general chemistry are departing from the predominantly analytical phase and are dealing more with the physical chemistry of the in-

[2] *J. Eng. Educ.*, **18**, 73 (Sept., 1927).

[3] *Ibid.*, **17**, 815 (Apr., 1927).

organic compounds. While this trend is in the right direction, the subject matter so taught is not usually adequate as a preparation for the chemistry of the power plant for it does not deal with the electrochemistry of corrosion, or the high temperature reactions of ash and slag. Of the courses which follow this, that of physical chemistry would most nearly complete the preparation of direct value to these men. However it does not usually occur in the curricula until advanced years, and is usually omitted from mechanical or electrical courses. Without detracting from the courses in the chemistry of engineering materials which are sometimes given to engineers, I would suggest a stronger fundamental training in physical chemistry because of its direct application to so many of these problems. Furthermore, it has been suggested that all men so trained should have a working knowledge of chemistry which is at least equivalent to their knowledge of electrical subjects. In most engineering curricula this would represent an increase in the amount of chemistry taught.

Manufacturers Honor Swedish Chemist Scheele on Sesquicentennial of His Discovery of Glycerin. The debt of modern science and industry to Karl Wilhelm Scheele, distinguished Swedish chemist and discoverer of glycerin, was recognized recently at the annual meeting in Chicago of the Association of American Soap and Glycerin Producers, representing the leading soap manufacturers of the country. The association sent to Crown Prince Gustaf Adolf, Honorary Member of the Royal Academy of Sciences of Sweden, a message felicitating him on the part played by his country in the development of glycerin products.

December 19th was the 187th anniversary of Scheele's birth and 1930 marked the sesquicentennial of his discovery made 150 years ago. Although regarded as a relatively unimportant discovery at the time, glycerin has come to be one of the most widely used substances known to science and industry, being a necessary ingredient of almost countless drugs, toilet preparations, and foods. The most modern use for the product is as an anti-freeze for automobile cooling systems, since it will not freeze at low temperatures and will neither boil nor evaporate at normal automobile operating heat. Nearly a million cars were protected with radiator glycerin last winter, and the number this season promises to exceed the million mark.

The following message was sent to the Crown Prince of Sweden, signed by Sidney M. Colgate, President of the Association:

"The Association of American Soap and Glycerin Producers, in annual convention at Chicago, desires to extend to your Highness as Honorary Member of the Royal Academy of Sciences an expression of gratitude and felicitation on the occasion of the hundred and fiftieth anniversary of the discovery of glycerin by the distinguished Swedish chemist, Karl Wilhelm Scheele. This contribution of your countryman to science and industry becomes increasingly valuable each year, and the approaching anniversary of the birthday of this distinguished son of Sweden will see the use of glycerin more widespread than ever before, not only in the arts and sciences but also in its recently discovered capacity as an anti-freeze in automobile cooling systems. As representatives of the leading factors in the American glycerin industry, we ask your Highness to accept this message of congratulation on your country's great contribution to modern science and industry and to motoring."

TEACHING INORGANIC CHEMISTRY TO THOUSANDS*

WILLIAM F. EHRET, WASHINGTON SQUARE COLLEGE, NEW YORK UNIVERSITY, NEW YORK CITY

About two years ago an article appeared in THIS JOURNAL[1] describing the remarkable growth of the chemistry department of Washington Square College. At present the annual enrolment in beginning chemistry is almost 1400. This is a larger number than the total annual enrolment (all courses) of 70% of our accredited American universities and colleges. Table I, compiled by the writer from data found in "American Universities and Colleges,"[2] will give an idea of the general distribution of students in our institutions of higher learning. All the colleges and universities on the accredited list of the American Council of Education (1927) were included in making the table. They number 384. The table is reproduced simply for the convenience of those who may wish to make comparisons similar to the one above.

TABLE I

Total annual enrolment	Percentage of total number of colleges and universities	Total annual enrolment	Percentage of total number of colleges and universities
Less than 500	35	Up to 500	35
Less than 750	54	500–750	19
Less than 1000	60	750–1000	6
Less than 1400	70	1000–1400	10
Less than 2000	78	1400–2000	8
Less than 2500	82	2000–2500	4
		Over 2500	18

The main purpose of this article is to describe (1) the organization of the teaching unit, and (2) the methods used in imparting annually to such a large number of students a goodly portion of the body of facts and theories called inorganic chemistry. We shall give the first matter but scant attention since the organization of the teaching unit is of minor importance and its size will vary from college to college.

The Teaching Unit

We have nine lecturers, including one associate professor, four assistant professors, and four instructors. The student listens to two or three lectures per week depending upon whether or not he has been "exposed" to chemistry in secondary school. The lectures are supplemented by adequate demonstrations, lantern slides, and motion pictures. Attendance

* Presented before the Division of Chemical Education of the A. C. S. at Minneapolis, Minnesota, September 10, 1929.

[1] MacTavish, Wm. C., THIS JOURNAL, **5**, 455–6 (Apr., 1928).

[2] Robertson, "American Universities and Colleges," Charles Scribner's Sons, New York City, 1928.

at the showing of the latter is voluntary. During the coming year it is proposed to further supplement the lectures by conducting monthly trips to industrial plants. The size of the lecture sections varies considerably due to limitations of space and time. Three sections number approximately 250 students; five sections have approximately 100; three or four sections have approximately 50 students.

The laboratory instruction, quiz, and recitation work is carried on mainly by thirty graduate assistants although the instructors and professors are also assigned to laboratory and quiz duties. Each laboratory of sixty students has a teaching personnel of three; one experienced graduate assistant or instructor and two graduate assistants, usually less experienced. The students are apportioned among the three assistants. The quiz and recitation hour, comprising thirty students to the class, is presided over by one of the professors, an instructor, or by an experienced graduate assistant.

Method of Teaching

So much for the teachers, now for the teaching. The lecturers follow a standard textbook rather closely. This is necessary since the examinations which come each quarter-semester are the same for all students enrolled in the course. Needless to say the coöperation of all the lecturers is required in setting the questions for these examinations. In order to coördinate the work in the laboratory and quiz sections with the lectures a schedule is posted each semester which gives the date and subject of each lecture, the experimental work to be performed each week in the laboratory and the work to be undertaken each week in the quiz sections. Besides this, one of the lecturers acts as overseer of the laboratories and quiz sections thus helping to keep them all coördinated and functioning in an efficient way.

In this college we consider the laboratory as a most important if not the most important adjunct in the teaching of inorganic chemistry. It is here that the instructor and the student come in close contact and it is here that the most effective teaching can be done. In order to insure the latter, a weekly assistants' meeting is held at which plans are laid for the conduct of the laboratories during the following week. This brings harmony into the group and makes for uniformity in the facts to be presented, methods of presentation, and experiments to be performed. In our laboratory instruction we have established several rules which we believe are fundamental to success. They are:

1. *All the assigned work is to be done independently by each student.* If an experiment requires working together in pairs or larger groups it is best to omit it or have it carried out in the form of a demonstration by the instructor or assistant in charge of the laboratory.

2. *As much of the manual work is to be performed by the student as possible.* This is to insure the proper coördination of mind and hand and the acquisition of the dexterity so necessary to our future chemists, physicists, physicians, and dentists. The assistants are requested to do as little lecturing or demonstrating as is compatible with the smooth running of the class as a whole.

3. *Instruction is to be mostly of the man to man or canvassing type.* The laboratory instructor passes from student to student, spends five or ten minutes with each one, asks questions and corrects errors in statements, notes, or apparatus. This *individual instruction* and questioning is most important and when properly carried out is not only an effective teaching tool but helps to obtain a reliable estimate of the student's knowledge and ability.

4. *The student is to keep notes and answer questions as directed in the laboratory* exercises. At the end of each laboratory session the assistant receives the notes and goes over them carefully, underscoring the errors. These notes are returned to the students at the beginning of the next laboratory session.

The quiz or recitation hour is one which, in the opinion of the writer, should form a part of every inorganic chemistry course. During this hour the student can let *his* light shine forth. Here, in a small responsive section, he can ask questions, think out loud, voice opinions, engage in *repartee*—all of course if the instructor has the class well in hand and controls as well as encourages this active type of recitation. The procedure followed in our quiz section is:

1. *A written quiz for ten–fifteen minutes starts the hour.* This kills two birds with one stone. It places a penalty on tardiness and gives an additional weekly grade with minimum loss of time. The instructor grades these quizzes and returns them to the student at the next meeting.

2. The remainder of the hour is given over to *an informal quizzing and discussion of the problems and questions assigned* by the weekly schedule.

The reader may sit back, wonder, and finally ask the perfectly natural question, "This all seems very well on paper, but how can you be sure it is working in practice?" The answer is, firstly, by proper oversight and, secondly, by requiring that the laboratory and quiz instructors and assistants turn in fortnightly reports of the grades and progress of each student under their care. Each instructor has a report blank for each class, the blank being large enough to accommodate all the grades for one semester. This not only serves as an effective check on assistants but it gives the instructor an excellent means of estimating the final grades of his students.

Another natural question would be, "Is this system as successful in small colleges as in large?" The author knows of two smaller colleges where

it has been tried and found quite satisfactory. In fact the smaller the college the easier it becomes to insist on *individual work* on the part of the student and *individual instruction* on the part of the assistant.

In concluding, the writer wishes to thank his colleagues at New York University and other institutions for their valuable suggestions and contributions toward making this particular system of teaching freshman chemistry a success.

Pioneer of Wave Mechanics Is Nobel Prizeman in Physics. One of the modern Alices in the wonderland of the newer physics, Duc de Broglie, scientific scion of a proud French family and member of the French Academy by scientific right as he is royalist by inheritance, is wearer of the Nobel laurels for physics for 1929.

In this high award, physicists see a compliment to a new way of looking at the phenomena of light, electricity, and other stuff of which the universe is made. For Duc de Broglie was the pioneer in the development of that most modern branch of physics, "wave mechanics," which the German physicist, Schroedinger, developed to an even greater extent.

The theory of wave mechanics as propounded by de Broglie and Schroedinger makes the differences between matter and radiation a shadowy borderland. An electron, the unit of electricity and the smallest particle of matter, becomes a sort of manifestation of a group of waves, while waves of light or other radiation at times take on the properties of particles. And then at other times matter is best explained as acting like waves of radiation.

All this is disconcerting to those who learned about light, X-rays, and other radiations some years ago when they were considered wave motions. Despite the new wave mechanics, the classical wave theory of radiation accounts for ordinary optical phenomena with satisfaction and for practical purposes it is not thrown overboard. Yet wave mechanics explains some mysteries unsolved by earlier conceptions and therefore the physicist is in the position of having more than one fundamental law. He uses the one that fits best, confident in the hope that future progress will destroy their apparent inconsistencies.

One daring prediction made by Duc de Broglie when he first developed his wave mechanics a few years ago was fulfilled by the discovery of the American physicists, C. J. Davisson and L. H. Germer, that electrons, particles of matter, act like waves in the same sense that light and X-rays are waves.—*Science Service*

Acids from Burning Coal Make Exposed Copper Green. The green patina that appears on copper roofs or drain pipes after years of service and that gives the metal its attractive appearance is due chiefly to sulfuric acid present in the air from coal smoke. This conclusion was announced at the meeting at Duesseldorf, Germany, of the Institute of Metals, an English society holding its first meeting in Germany, by Dr. W. R. J. Vernon and L. Whitby of the Chemical Research Laboratory at Teddington.

The two metallurgists studied samples of copper from buildings in London and other parts of England. Some were as old as three hundred years. In the city specimens, the patina consisted of basic copper sulfate, caused by the action of atmospheric sulfuric acid. A piece of telegraph wire, exposed for 13 years within 200 yards of the sea, showed a patina consisting of basic copper chloride, the chlorine having been furnished from the salt water. At first, they found, the red copper turns black, but then the green patina develops later, and remains indefinitely.—*Science Service*

WOMEN'S CLUB STUDY COURSE IN AMERICAN CHEMISTRY*

This Women's Club Study Course in its present form is made possible through the generosity of Mr. Francis P. Garvan, president of The Chemical Foundation. It has been prepared by a committee of the Division of Chemical Education of the American Chemical Society in coöperation with the Bureau of Women's Clubs, University of Arkansas, Fayetteville, Arkansas..

The course is arranged about the following reference books which are furnished by the publishers and by The Chemical Foundation at a price which does not consider profit, but only with the hope that the women of the United States may come to see the fundamental importance of chemistry in the life of America today.

References

(1) "American Chemistry," by Harrison Hale; published by D. Van Nostrand Company, New York, second edition, **1928.**

(2) "Chemistry in Agriculture," Joseph S. Chamberlain, editor; published by The Chemical Foundation, Incorporated, New York, **1926.**

(3) "Chemistry in Industry," Volume I, Harrison E. Howe, editor; published by The Chemical Foundation, Incorporated, New York, **1924.**

(4) "Chemistry in Industry," Volume II, Harrison E. Howe, editor; published by The Chemical Foundation, Incorporated, New York, **1925.**

(5) "Chemistry and the Home," by H. E. Howe and F. M. Turner, Jr.; published by Charles Scribner's Sons, New York, **1927.**

(6) "Creative Chemistry," by Edwin E. Slosson; published by The Century Co., New York, **1919.**

(7) "Chemistry in Medicine," Julius Stieglitz, editor; published by The Chemical Foundation, Incorporated, New York, **1928.**

(8) "The Romance of Chemistry," by William Foster; published by The Century Company, New York, **1927.**

Additional material of value will be found in other books and in the magazines and newspapers. The JOURNAL OF CHEMICAL EDUCATION, the official publication of the Division of Chemical Education, is of unusual value.

For detailed information concerning the course write: HARRISON HALE, *Chairman*, Women's Club Study Committee, University of Arkansas, Fayetteville, Arkansas.

Outline

There has been a general movement in recent years to make the science of chemistry, which so strongly influences our everyday home and national life, understandable to those outside the field of research and production. The course outlined below is non-technical, designed to give that newness

* Report of Division of Chemical Education A. C. S. Committee on "Women's Club Study Course in Chemistry." The chairman of this committee is Harrison Hale, University of Arkansas, Fayetteville, Ark.

of vision and awakening of interest which result from a knowledge of what this all-important science is doing and may do for us. The suggested skeleton outline is as follows:

AMERICAN CHEMISTRY

1. Chemistry—The Ball-Bearings of Progress
2. Water, Sanitation, and Medicine
3. Feeding the Family
4. Clothing the Family
5. Painting the Picture of Progress
6. Fuel for Fire and for Force
7. Dinner Plates and Drain Pipes
8. Rubber
9. Electro-Chemistry and the Kitchen
10. Gold, King of Metals, and Iron, the President
11. In Peace and in War
12. American Chemistry and the Future

A similar course has been offered by the Bureau of Women's Clubs, University of Arkansas, since 1923 and has been studied by various clubs in different states.

PROGRAM I.—CHEMISTRY—THE BALL-BEARINGS OF PROGRESS

"Chemistry is the intelligence department of human industry."

Report of the Twelfth Census of the United States

"When the America of today understands a problem it is well on the way toward being solved." *Francis P. Garvan*

"No woman has to be a chemist to be mentally enriched, any more than she has to be a chemist to be materially enriched by chemistry's achievements and possibilities." *A Plea to American Women by Presidents of Five Prominent Women's Organizations*

References

(1) "American Chemistry," Preface and Chapter I.
(3) "Chemistry in Industry—I," Foreword and Chapters I, X.
(5) "Chemistry and the Home," Preface and Chapter I.
(6) "Creative Chemistry," Introduction and Chapter I.
(7) "Chemistry in Medicine," Foreword and Chapter I.
(8) "Romance of Chemistry," Chapters I, XXVI, and pp. 59–60.

Assignments

1. What is chemistry? *See dictionary and encyclopedias; also Reference* (3), p. v. The addition of a single letter, or element, entirely changes the meaning of a word; so of a compound; thus:
   "Not" is an adverb, while "note" is different—a noun or verb.
   So in chemistry H_2O is water; H_2O_2 is hydrogen peroxide.
   HgCl is calomel; $HgCl_2$ is corrosive sublimate.
   See Reference (5), pp. 18–20; (7), Foreword ix–x and pp. 1–23.
2. Early history in America. *Reference* (1), pp. 1–2; (3), p. 130.

3. Fundamental importance to American industry; also in every phase of life. It is impossible to name any three things of importance not connected with chemistry. Try it. *Reference* (1), pp. 2–3; (3), v–vii, 1–20; (5), 1–26; (6), 1–13; (8), 436–447.
4. Where was the first chemical society in the world? Are the three statements made before that society in the eighteenth century still true? *Reference* (1), pp. 3–4.
5. Founding of American Chemical Society; suggested by whom? Size and importance. Publications. *Reference* (1), pp. 4–5; (8), 59–60.
6. Chemistry in American colleges and universities; prerequisite in medicine, engineering, and home economics. *Reference* (1), pp. 5–6; (6), Introduction.
7. How can industry and college coöperate? Advantages to each. Mellon and Battelle Institutes and their work. *Reference* (1), pp. 6–7.
8. Strength and weakness of American chemistry. The Chemical Foundation, Inc. *Reference* (1), pp. 8–9; (7), x–xiv.
9. Summarize the importance of chemistry to America. *Reference* (5), pp. 1–21.

See articles in magazines and newspapers. A talk by some local chemist might well accompany this or later programs.

PROGRAM II.—WATER, SANITATION, AND MEDICINE

"Each human body is now recognized to be a chemical factory."

See Reference 7

References

(1) "American Chemistry," Chapter II.
(4) "Chemistry in Industry—II," Chapters XVII, XXI, XXII.
(5) "Chemistry and the Home," Chapters V, XIV.
(7) "Chemistry in Medicine," entire.
(8) "The Romance of Chemistry," Chapters VII, XXV.

Assignments

1. Is there any other material more important for the physical welfare of a family than its water supply? *Reference* (1), p. 11; (8), 107.
2. How is the purity of a water supply tested? What diseases are waterborne? State Boards of Health often make bacteriological tests. *Reference* (1), pp. 11–13; (4), 299–300, 378–381; (7), 323–331.
3. What two methods are generally used in purifying a city water supply? Summarize results of purification. How can a family supply be purified? How is your city water safeguarded? *Reference* (1), pp. 13–19; (4), 383–392; (7), 331–339; (8), 103–104.

4. What causes hard water? How may it be softened? Advantages of soft water. *Reference* (1), pp. 20–21; (4), 295–300, 381–383; (5), 95–113; (8), 104–108.
5. How is soap made? What is an important by-product in the manufacture of soap? *Reference* (4), pp. 360–77; (5), 97–100; (8), 132–134.
6. Necessity of proper sewage disposal. How accomplished for the home? for the city? What becomes of your home or city sewage? *Reference* (1), pp. 21–24; (7), 358–373.
7. What has caused the lessening of the frequency of epidemics, such as yellow fever and typhoid? *Reference* (1), pp. 24–26; (3), 95–96; (7), 331–339; 543–699.
8. How has chemistry helped in "lengthening the life-line?" Future possibilities. *Reference* (1), pp. 26–28; (7), 701–720.
9. List the ways in which the chemist aids the physician. *Reference* (1), pp. 27–28; (5), 260–262; (7), 417–541; (8), 420–429.
10. Make a list of diseases which may now be largely controlled by the coöperation of the chemist, bacteriologist and physician; of those not yet under such control. *Reference* (1), pp. 27–28; (5), 257–273; (7), 543–699; (8), 420–435.
11. Is the coöperation of the individual and of the public needed also? How? Apply to local, state, and national situations. *Reference* (7), pp. ix–xiv.

See articles in magazines and newspapers.

PROGRAM III.—FEEDING THE FAMILY

The growth of all food depends upon chemistry.

References

(1) "American Chemistry," Chapter III.
(2) "Chemistry in Agriculture," entire.
(3) "Chemistry in Industry—I," Chapters V, VIII, XIV.
(4) "Chemistry in Industry—II," Chapter V.
(5) "Chemistry and the Home," Chapters II, XVIII.
(6) "Creative Chemistry," Chapters III, IX, X, XI.
(7) "Chemistry in Medicine," Chapters III–1, IV, V, VII–2.
(8) "The Romance of Chemistry," Chapters XIII, XIV, XXIII, XXIV.

Assignments

1. Why do we eat? *Reference* (1), pp. 31–32.
2. Classification of foods under five heads. Name certain foods rich in each. *Reference* (1), p. 32; (3), pp. 77–84, 200–235; (6), 196–217; (8), 400–408.
3. What are vitamins? Where do they occur? *Reference* (1), pp. 33–34; (2), 183–185, 255–282; (5), 27–36; (8), 414–419; (7), 112–144.

4. What and how much shall we eat? *Reference* (1), pp. 33–34; (7), 73–111; (8), 408–414.
5. Criticize constructively the food used in the average American family in ordinary circumstances; in a poor family; in a rich family. Compare with Sherman's advice. *Reference* (1), pp. 34–35; (2), 283–316, 335–357; (7), 145–190.
6. Is the diet of today more wholesome than that of fifty years ago? What forces are at work to improve food conditions? What others might be employed? *Reference* (2), pp. 358–394; (4), 82–94; (5), 343–350; (6), 181–195; (7), 340–355.
7. How is cotton-seed oil changed to a semi-solid fat? *Reference* (1), pp. 34–35; (3), 82–83; (5), 36–37; (6), 202–205; (8), 167.
8. Name and describe the agricultural triad, telling how much of each is ordinarily found in the soil and how much is taken from the soil by various crops. *Reference* (1), pp. 35–39; (2), 92–105; (3), 103–106; (5), 330–343; (8), 389–394.
9. Discuss four sources of nitrogen for fertilizers. What must be finally our chief source? To what extent is this being used now? *Reference* (1), pp. 39–46; (2), 76–91; (3), 113–118; (5), 335–341; (8), 141–142, 167–168, 188–197.
10. Where is phosphorus for fertilizers obtained? Why is the rock usually treated with sulfuric acid? *Reference* (1), pp. 46–48; (2), 92–94; (3), 106–109; (8), 204–210.
11. What is the source of most of our potash? Could the United States supply itself? *Reference* (1), pp. 48–54; (2), 95–105; (3), 109–113; (5), 332–335; (6), 37–59; (8), 139–140.
12. Should America produce or import her nitrogen and potash fertilizers? Why? *Reference* (1), pp. 39–46, 52–54.

See articles in magazines and newspapers. A talk by a local chemist might well accompany this or other programs.

PROGRAM IV.—CLOTHING THE FAMILY

"She is not afraid of the snow for her household; for all her household are clothed with scarlet." *Proverbs: 31, 21*

References

(1) "American Chemistry," Chapter IV.
(3) "Chemistry in Industry—I," Chapters V, XV, XXI.
(4) "Chemistry in Industry—II," Chapter XVIII.
(5) "Chemistry and the Home," Chapters VI, VII, VIII.
(6) "Creative Chemistry," Chapters VI, VII, XI.
(8) "The Romance of Chemistry," Chapter XXVI.

Assignments

1. Define textiles (see dictionary). Imagine life without textiles. *Reference* (1), p. 57; (5), pp. 114–116.

2. Classify fibers. Could cotton rightly be called the most important? Is the production by the South of so large a percentage of the world's supply an advantage? *Reference* (1), p. 57; (3), pp. 75–77; (6), 196–199.
3. What is the chief chemical constituent of cotton? of linen? How are they bleached? *Reference* (1), pp. 58–61; (3), p. 367.
4. Compare the chemical elements in cotton with those in silk; in wool. How can cotton be distinguished from linen? from wool? *Reference* (1), pp. 59, 63; (5), 120–125; (6), 110–115.
5. In Holland some wear shoes made from wood by mechanical changes; in America many wear stockings made from wood by chemical changes. Importance and use of man-made fibers. *Reference* (1), pp. 64–66; (3), 369–372; (4), 305–328; (5), 144–148; (6), 116–122; (8), 439–442.
6. How are these products related to cotton, artificial leather, cellophane, collodion, mercerized cotton, photographic films, celluloid, patent leather, gun cotton, pyroxylin lacquer, imitation ivory? *Reference* (1), pp. 58, 66–69; (3), 75–77, 367–369; (6), 115–126, 128–135; (8), 200, 439.
7. Why do large manufacturers of explosives produce so wide a variety of peace products? *Reference* (1), pp. 66, 228–229.
8. How is silk prepared? How is it treated to increase its weight? its rustling? African savages are said to wear the tops of tin cans for ornaments; we wear our tin as oxides. Explain. *Reference* (1), pp. 61–2; (5), 131–44; (8), 442.
9. How are animal fibers bleached? Compare the fibers of cotton, linen, silk, and wool. *Reference* (1), pp. 58–64; (5), 148–153.
10. Why is summer clothing made of linen and winter clothing made of wool? *Reference* (1), pp. 59, 62.
11. Discuss manufacture, importance, and varied use of paper. *Reference* (1), pp. 69–72; (3), 236–252; (5), 131–153; 154–170; (6), 110–114.
12. Can you think of any waste material occurring in large quantities, the fiber of which might be used commercially? *Reference* (1), pp. 67–68; (8), 189.

See articles in magazines and newspapers.

PROGRAM V.—PAINTING THE PICTURE OF PROGRESS

"The whole fabric of modern civilization becomes each day more and ever more interwoven with the endless ramifications of applied chemistry."

L. H. Baekeland

References

(1) "American Chemistry," Chapter V, VIII.
(3) "Chemistry in Industry—I," Chapter XVI, XIX.
(4) "Chemistry in Industry—II," Chapters IV, XIV.

(5) "Chemistry and the Home," Chapter XI, XVII.
(6) "Creative Chemistry," Chapters IV, V, VII.
(7) "Chemistry in Medicine," Special References (see 11 below).
(8) "The Romance of Chemistry," Chapter XXII, XXVI.

Assignments

1. What is paint? What are the most important white pigments? How is each made? *Reference* (1), pp. 90, 149–155; (4), 232–237.
2. Name one or two common pigments of each major color. What is meant by reinforcing pigments? Ordinarily would you prefer a pure lead or a pure zinc paint or a mixture? Give reasons. *Reference* (1), pp. 154–158.
3. What materials are used to form the vehicle? Which is to be preferred? What driers? Examine analyses of pigment and vehicle on paint cans at local stores. What do they show? *Reference* (1), pp. 159–165; (4), 246–247; (5), 216–218.
4. What is varnish? What fossil and recent resins are used? Tell the story of pyroxylin lacquers. *Reference* (1), pp. 165–167; (4), 232, 238, 242–246; (5), 218–222.
5. What is bakelite? Its other uses than in varnish are more important; name some of them. *Reference* (1), pp. 167–169; (3), pp. 329–339; (6), 136–144; (8), 442.
6. Discuss the importance of paint both for wood and other materials. Has the use of prepared paints increased? Is this advantageous? *Reference* (1), pp. 169–171; (4), 243–247, 250–259; (5), 210–218.

   Paint is usually applied to the surface. Chemistry, while applying to the surface, also permeates "the whole fabric of modern civilization." Nowhere is this more clearly seen than in coal tar and its products.
7. What are the two primary products of the destructive distillation of coal? Two by-products? Compare beehive and by-product coke ovens. *Reference* (1), 74–77; (6), 60–64; (8), 438.
8. How was coal tar at first regarded? Early uses? Approximately how many substances does it contain? How are they separated? Does it contain any dye? How are dyes made from it? *Reference* (1), pp. 77–84; (4), 58–61; (5), 321; (6), 60–72.
9. Outline briefly the history of the discovery of the first artificial dye and the development of the artificial dye industry, showing how it started in England, was dominated by Germany, and has recently been developed in America. *Reference* (1), pp. 84–91; (4), 61–79; (5), 320; (6), 72–84; (8), 378–381.
10. How important are dyes in themselves? Is there any one present, part of whose clothing is not colored by coal-tar dyes? Compare cost of dye with cost of article dyed. *Reference* (1), pp. 87–92.

11. How are dyes related to foods? drugs? perfumes? flavoring extracts? photographic materials? national defense? Have natural dyestuffs been entirely displaced? *Reference* (1), pp. 92–94; (3), 274–293; (4), 79–81; (5), 246; (6), 93–109; (7), 354–5, 425, 537, 589–597, 703; (8), 430–431.
12. Should an American dye industry be maintained? Note its constant value in the war against insects and disease, as well as in ordinary warfare. *Reference* (1), pp. 85–109.

See articles in magazines and in newspapers.

PROGRAM VI.—FUEL FOR FIRE AND FOR FORCE

"They sit conferring by the parlor fire." *Shakespeare*

References

(1) "American Chemistry," Chapter VI.
(3) "Chemistry in Industry—I," Chapters III, IV, IX, XVII.
(4) "Chemistry in Industry—II," Chapter II.
(5) "Chemistry and the Home," Chapters XIV, XVII.
(8) "The Romance of Chemistry," Chapter V, VII, VIII, XI, XXI, XXII.

Assignments

1. Trace the importance of fire as center of the home both in legend and in history. Note associations with "fireside," "hearthstone." (*See encyclopedia.*) *Reference* (1), p. 96; (8), pp. 66–74.
2. Of how great importance is wood as a fuel? Compare heating value of wood and coal; of different kinds of wood; of different kinds of coal. *Reference* (1), pp. 99–100.
3. Classify fuels. Show sources of energy and its utilization in the United States. *Reference* (1), pp. 98–99; (8), 348–352.
4. How long has coal been used in the United States? When did its consumption become as great as one ton per person? What is the present consumption? Compare coal production by countries and by states. How much anthracite coal is produced in America? Where? *Reference* (1), pp. 96–102; (3), 58–74.
5. When did the American petroleum industry begin? What is its present extent? Its future possibilities? How does oil compare with coal as a fuel? *Reference* (1), pp. 102–107; (3), 294–311; (5), 322–326; (8), 366–370.
6. Discuss oil shales as a source of fuel. *Reference* (1), pp. 106–107; (3), 309–310; (5), 323.
7 Discuss the industrial possibility of wood alcohol; of grain alcohol. *Reference* (1), pp. 107–109; (3), 34–57; (5), 266–267; (8), 168–169.
8. What are the four most important fuel gases? How is each obtained? Compare their heating value. *Reference* (1), pp. 109–112; (3), 125–126; (8), 372–375.

9. What are the chief products of the destructive distillation of coal? Of wood? Of the fractional distillation of petroleum? Which products are of decided commercial importance? *Reference* (1), pp. 112–114; (3), 65–74, 305–309; (5), 318–319.
10. How is helium obtained? Name two uses. Why is it not used as a fuel? What are its industrial possibilities? *Reference* (1), pp. 110–111; (3), 124–125; (4), 30–34; (8), 96–97.
11. How is the yield of gasoline increased? How can greater efficiency in its use be reached? *Reference* (1), pp. 105–106, 114–115; (3), 124–125; (4), 30–34; (8), 96–97.
12. Show how practically all of our heat and energy come from the sun. Discuss energy supply of future. North America is said to have nearly 70 per cent of the world's coal reserves. Is this to be thought of chiefly as an advantage or as a responsibility? *Reference* (1), pp. 98, 114–115, 241–242; (5), 314–326.
13. "Future sources of energy" or "untapped sources of energy"—wind, waves, earth's heat, atmospherical electricity, sun's rays, etc.

See articles in magazines and in newspapers.

PROGRAM VII.—DINNER PLATES AND DRAIN PIPES

"Little drops of water, little grains of sand
Make the mighty ocean and the pleasant land."

Julius Fletcher Carney

References

(1) "American Chemistry," Chapter VII.
(3) "Chemistry in Industry—I," Chapter X.
(4) "Chemistry in Industry—II," Chapters VI, XV.
(5) "Chemistry and the Home," Chapters IV, XV.
(8) "The Romance of Chemistry," Chapter XVII, XIX.

Sand is made up entirely of silicon and oxygen, while 88.8% of water is oxygen. Consult the diagram and see how nearly the nursery rhyme approximates scientific fact. Of course not all the oxygen is found in sand and water. *Reference* (1), p. 36.

Assignments

1. Name substances containing silicon. Silicates contain oxygen, silicon, and one or more metals. What are the silicate industries? *Reference* (1), p. 118.
2. How many different articles made of glass are in your home? How long has glass been made? When and where was it first made in America? *Reference* (1), pp. 118–120; (3), 130–132; (5), 67–90, 292–295.

3. What materials are used in manufacturing window glass (lime glass)? Note three methods of manufacture; also its action to ultra-violet rays. *Reference* (1), pp. 118–124; (3), 132–135; (5), 70–76; (8), 316–321.
4. How does cut glass (lead glass) differ in composition from window glass? To which is plate glass more closely related? How is glass colored? *Reference* (1), pp. 119, 123, 129; (3), 135–137, 140–144; (5), 85–86; (8), 321–322.
5. Trace the development of the optical glass industry in the United States. *Reference* (1), pp. 124–127; (3), 135–138; (5), 76–82; (8), 321.
6. What is clay? How widely distributed? Name two general classes of clay products. *Reference* (1), pp. 129–130; (4), 97–102; (8), 261–270.
7. Describe manufacture of brick, fire brick, and drain tile. *Reference* (1), pp. 130–133.
8. Note the steps in the manufacture of pottery that are common to all grades; note also differences, especially in quality of materials and in glazing. *Reference* (1), pp. 134–135; (4), 102–109; (5), 87–91; (8), 308–316.
9. How many different clay products are in use in and about your home?
10. Name three kinds of cement. Compare the amounts of each now used with those used thirty years ago. *Reference* (1), pp. 135–143; (4) 261–267.
11. What materials are used in the manufacture of portland cement? Name three steps in manufacture. Note chemical control. *Reference* (1), pp. 138–142; (4), 267–278.

See articles in magazines and in newspapers.

PROGRAM VIII.—RUBBER

"No greater romance is to be found in the world of industry today than that of rubber." *J. A. Orb, in Scientific American*

References

(1) "American Chemistry," Chapter IX.
(3) "Chemistry in Industry—I," Chapter XX.
(5) "Chemistry and the Home," Chapter X.
(6) "Creative Chemistry," Chapter VIII.
(8) "The Romance of Chemistry," Chapters XX, XXII.

Assignments

1. Note the discovery and naming of rubber. *Reference* (1), p. 173; (3), 340; (5), 159–160, 192–195; (6), 159–160.
2. Make a list of the uses of rubber, noting how uniformly it adds to the comfort of life. *Reference* (1), p. 173; (5), 190–192; (6), 163.

3. What is the source of rubber? How is Para rubber obtained and prepared for market? *Reference* (1), pp. 173–178; (3), 341–352; (6), 156.
4. What is meant by plantation rubber? Four tons of this were produced in 1900. Compare with present production. *Reference* (1), p. 175; (3), 341–345; (6), 155–157.
5. Where are these plantations located? How much of the world's production is grown and how much is used in the United States? Should there be rubber plantations in the Philippines? If so, why? *Reference* (1), pp. 135–176; (5), 193–195; (6), 156–158.
6. Note the wide fluctuations in the price of rubber. What is the reason for this? Is there a danger of producing more rubber than can be used? *Reference* (1), pp. 175–176; (6), 157, 163.
7. What is meant by vulcanizing rubber? By whom discovered? What is the chief difference in the composition of soft and of hard rubber products? Why? *Reference* (1), 178–180; (3), 346–347, 352–355; (5), 195–199; (6), 161–162; (8), 339.
8. What materials are added in the manufacture of rubber products? Why? *Reference* (1), pp. 180–181; (3), 349–351; (5), 199–200.
9. What is synthetic rubber? Is it now made to any great extent? Why? The future possibilities of synthetic rubber. Is reclaimed rubber used? *Reference* (1), pp. 181–182; (3), 355–356; (5), 206–209; (6), 145–155; (8), 363.
10. Can rubber be grown in the United States? Can rubber substitute be grown? Is this done now? Why? *Reference* (1), p. 176; (6), 158.
11. Tires have been decidedly cheaper and their usefulness and length of life have been greatly increased by means of accelerators and antioxidants. What are they? Note the development of the pneumatic tire. *Reference* (1), p. 180; (3), 351–352; (5), 200–205; (6), 162.

See articles in magazines and in newspapers. A talk by a local chemist might well accompany this or other programs.

PROGRAM IX.—ELECTROCHEMISTRY AND THE KITCHEN

"Every girl should know the chemist as her friend, because it will enable her to help him serve her, and because it will make the surroundings of the home much more interesting." *Robert E. Rose*

References

(1) "American Chemistry," Chapter X.
(3) "Chemistry in Industry—I," Chapters II, VI, VII, XIII.
(4) "Chemistry in Industry—II," Chapters VII, VIII, XX.
(5) "Chemistry and the Home," Chapters III, XI.
(6) "Creative Chemistry," Chapter XIII.
(8) "The Romance of Chemistry," Chapter X.

Assignments

1. What are the two distinct uses of the electric current? How long has electro-chemistry been applied to industry? *Reference* (1), pp. 185–187.
2. Next to oxygen and silicon what element occurs in largest amount in the earth's surface? What is clay? What is bauxite? *Reference* (1), pp. 136, 160–187.
3. Tell the story of the discovery of the method of obtaining aluminum from bauxite and of its present importance. What evidence have you observed in your own kitchen that impure aluminum rusts more rapidly than pure aluminum? *Reference* (1), pp. 187–189; (5), 52–58; (6), 245–248.
4. What has electrochemistry to do with nickel or chromium plating on a kitchen range? Other metal coatings? *Reference* (1), p. 187; (3), 187–191; (4), 131–138; (5), 222–229.
5. When and where was the first industrial electric furnace put into operation? List some of the products made by its use. *Reference* (1), pp. 190–195; (3), 21–33; (6), 249–251; (8), 159–160.
6. Note the part played by chemistry in the manufacture of a kitchen stove and of other household articles. Compare the kitchen of today with that of 25, 50, and 100 years ago. *Reference* (1), pp. 193–195; (3), 85–94.
7. What possible relation has calcium carbide, an electric furnace product, to the food cooked on this stove? *Reference* (1), pp. 41–45, 193; (8), 194.
8. Note the number of products obtained from the electrolysis of common table salt. *Reference* (1), pp. 26, 189–190; (3), 95–102.
9. What are steel alloys? What metals are used in making them? Of what use and advantage are they? *Reference* (1), pp. 193–194; (4), 354–359; (5), 58–64.
10. Why are so many electrochemical plants located at Niagara Falls? Consider this in the light of possible developments in your own state. What of the future of electrochemistry? *Reference* (1), pp. 185, 193, 195.

See articles in magazines and newspapers

PROGRAM X.—GOLD, THE KING OF METALS, AND IRON, THE PRESIDENT

"Gold is a living god, and rules in scorn
All earthly things, but virtue." *Shelley*

Iron is the most useful of metals.

References

(1) "American Chemistry," Chapter XII.
(3) "Chemistry in Industry—I," Chapters XI, XIII.
(4) "Chemistry in Industry—II," Chapter XX.
(5) "Chemistry and the Home," Chapter III.
(6) "Creative Chemistry," Chapter XIV.
(8) "The Romance of Chemistry," Chapters XVII, XVIII.

Assignments

1. Note the importance of metals as shown in their value and in their actual and relative increase in production. *Reference* (1), pp. 206–209; (3), 176–178; (4), 346–359; (5), 59–64; (8), 272–280.
2. What is a mineral? An ore? How do metals occur in nature? What two general methods are used for obtaining them from their ores? *Reference* (1), pp. 207–208; (3), 178–188; (8), 261, 272, 280–286.
3. How long has gold been used to measure value? Might some other measure be substituted? With increase in price of mining materials and of wages during the past two decades, why has the production of gold decreased? *Encyclopedia. Reference* (8), p. 276.
4. How does gold occur in nature and how is it obtained? *Reference* (1), pp. 219–221; (8), 272–276.
5. A king is sometimes considered largely as an ornament, while a president must serve. Consider the uses of the two metals on this basis and see if the title of this study is appropriate. Note the President's versatility. *Reference* (1), pp. 208–209; (6), 276–277.
6. What is the most common ore of iron? How is cast iron obtained from it? *Reference* (1), pp. 209–212; (3), 150–152, 155–156.
7. Name two other forms of iron and tell how each is obtained from cast iron. *Reference* (1), pp. 212–216.
8. Is it too much to say that the rate of growth and development of America has depended upon the Bessemer converter? Why? What other process for steel making has now come into more common use? *Reference* (1), pp. 214–217; (3), 147–149, 152–155.
9. The location of what cities is of interest in connection with iron ore, coal, and flux? *Reference* (1), p. 217; (3), 150–151.
10. How does the United States rank in the production of iron and steel? Of other metals? *Reference* (1), pp. 208, 221; *statistical reports, also.*
11. Compounds of gold are of little importance. Note importance of iron compounds in our bodies; in plants; in paints; elsewhere. *Reference* (6), pp. 263–270.
12. Note the importance of alloy steels. *Reference* (1), pp. 193–194; (4), 354–359; (5), 58–64; (6), 276–285.

See articles in magazines and newspapers.

PROGRAM XI.—IN PEACE AND IN WAR

"In peace and even more in war, chemistry paints the whole picture of progress." *A. Mitchell Palmer*

References

(1) "American Chemistry," Chapter XIII.
(2) "Chemistry in Agriculture," Chapters IV, X.
(4) "Chemistry in Industry—II," Chapters II, IX.
(6) "Creative Chemistry," Chapters II, XII.
(8) "Romance of Chemistry," Chapters XIII, XXIII, VIII, XIV.

Assignments

1. "The heart of humanity is set on peace." Is the real goal "peace regardless of security" or "lasting peace in permanent security?"
2. PROGRAM I has shown the importance of chemistry in peace. Must not real peace rest upon chemistry? *Reference* (1), p. 223.
3. We all hate war and pray for peace; no one more sincerely than the chemist, for he knows that the basis of war as of peace is chemical. Let us see how this is true, and how this war chemistry may be used for the purpose of peace. What is an explosion? What element is contained in nearly all explosives? *Reference* (1), pp. 224–225; (2), 76–91; (6), 14–17; (8), 188–191.
4. Classes of explosives. Uses and value of each in war and in peace. *Reference* (1), pp. 226–232; (6), 17–36; (8), 197–203.
5. Sir Alfred Nobel and the Nobel Peace Prize. Have explosives been a blessing or a curse to man? *Reference* (1), pp. 227–229; (6), 18; *Encyclopedia*.
6. Use of warfare gases; forbidden at the Hague; prohibition ratified by Germany and Great Britain, but not by United States. Why? *Reference* (1), p. 232; (6), 233–235.
7. What element is the basis of most warfare "gases?" Are all "warfare gases" really gaseous? Classification of "gases" and forms of attack. Is there an ideal warfare gas? *Reference* (1), pp. 232–237; (4), 15–35; (6), 21–22; 232–233; (8), 113–114.
8. The gas mask at first and now. Part taken by British women. *Reference* (1), p. 234; (6), 230–231.
9. Use of smoke screens. *Reference* (1), pp. 233–234; (8), 210.
10. Peace time uses of gas and gas masks. Why do large manufacturers of explosives produce so wide a variety of peace products? *Reference* (1), pp. 231–234, 65–68, 202; (2), 210–226; (8), 397–399.
11. Is war in any form ever "civilized?" Can any objection be offered to "gas" which has not been raised against every new weapon? Is its prohibition practical? Does the Kellogg pact help toward a real

solution of the problem of war? How? *Reference* (1), pp. 237–238.
See articles in magazines and newspapers.

PROGRAM XII.—AMERICAN CHEMISTRY AND THE FUTURE

"A civilization which recognizes the paramount value of scientific investigation, and which furnishes to it resources and the recognition of public esteem, is certain to outstrip its contemporaries in its promotion of the breadth and depth of human life." *James R. Angell*

References

(1) "American Chemistry," Chapter XIV.
Review all references.

Assignments

1. Ask each member to report two outstanding facts of chemistry in America, as each sees it. *All references.*
2. Summarize briefly chemical development in America before the World War. *Reference* (1), 240. *Other references.*
3. Outline war development, stating new industries developed in America. *Reference* (1), pp. 24–26, 74, 89–90, 124–128, 166, 223, 238, 240–241.
4. Compare America's resources and power with those of other nations. Should these facts cause a feeling of boastfulness or of deep responsibility? *Reference* (1), pp. 241–242.
5. Is America abreast of the world's development in all phases of chemistry? Note the consequences of weakness at one time in organic chemical research. *Reference* (1), p. 241.
6. What is America's record now concerning waste? *Reference* (1), pp. 242–243.
7. What really is "The Spirit of America?" Discuss, criticize, and, if desired, rewrite. *Reference* (1), pp. 243–248.
8. Are we only at the "sunrise of America's chemical development?" What may cause an eclipse? What relation does research bear to America's welfare? *Reference* (1), pp. 243–248.
9. Note research work now done in America. Is a chemical or a combined scientific attack on a problem preferable? *Reference* (1), pp. 245–248; (6), Introduction.
10. Note the service of chemistry in (*a*) conservation, (*b*) thrift, (*c*) city beautification, (*d*) health preservation.
11. Compare the present achievements of chemistry with the claim of the alchemist and the efforts of the early medical chemist. What of future possibilities along these lines? *Reference* (1), pp. 247–248.
12. What is meant by American chemical independence? How will it best be won? What is the part of each loyal American? *Reference* (1), pp. 247–248.
See articles in magazines and newspapers.

SUMMARY AND REVIEW

1. Make an effort to reach six or more definite conclusions upon which the group can agree.
2. Are there other matters of outstanding importance in chemistry in America?
3. How has this study affected your outlook on life (vision)? Your interest in current reading?

This summary may be treated in various ways:

1. It may be omitted entirely.
2. It may be combined with the twelfth meeting.
3. An entire meeting may be given to it. If this is done, the study of the questions given above may be general, or upon the basis of the reference books used, one being assigned to one or more members.
4. An entirely different plan of review may be better in certain cases.
5. An address by a local chemist might feature the meeting.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for JUNIOR METALLURGIST. Applications must be on file with the Civil-Service Commission at Washington, D. C., not later than January 21, 1930. The examination is to fill vacancies occurring in the Federal classified service throughout the United States. The entrance salaries range from $2000 to $2500 a year. Higher salaried positions are filled through promotion.

The duties will consist of general metallurgical work connected with the fabrication of manufactured articles, either ferrous or non-ferrous; general metallurgical work including process control, physical testing of metallurgical materials or ores, microphotography, and research work on a large variety of metallurgical problems.

The optional subjects are (1) physical metallurgy and (2) recovery metallurgy.

Competitors will be rated on practical questions on general metallurgy, elementary physics, elementary chemistry, and the optional subject chosen, and on a thesis to be handed to the examiner on the day of the examination.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or from the secretary of the United States Civil-Service Board of Examiners at the post office or customhouse in any city.

Autumn Leaves Red Because of Alcohol. Leaves turn red in autumn from the same cause that turns noses red at any time—alcohol. Such is the declaration of Samuel G. Hibben, lighting specialist of the Westinghouse Lamp Company, who has been investigating the effect of sunlight on living things.

Frost, usually credited as the agent in autumnal leaf-color changes, really has very little to do with the case, Mr. Hibben says. Leaves age, and when they grow old they do not function as efficiently as they did when they were young. Certain chemical products accumulate, among them various alcohols, and these act on the other substances in the leaves to give the bright-colored pigments.—*Science Service*

CONDUCTANCE TITRATIONS IN NON-AQUEOUS SOLVENTS AND THEIR USE AS A PEDAGOGICAL AID

WALTER W. LUCASSE AND HAROLD J. ABRAHAMS, UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PENNSYLVANIA

Since Kohlrausch first indicated that titrations could be carried out by means of conductance measurements, numerous workers have applied this method to a large number of systems. These investigations have been made to show the scope of the method, its accuracy in specific cases or to meet some particular need. Such titrations have been introduced into the textbooks and laboratory manuals of physical chemistry both to illustrate an analytical procedure of increasing importance and to give the student greater insight into the process of electrical conductance.[1]

Considering only electrolytic conductance we may say, in general, that the conductance of a substance or a solution is due to the ions present. The magnitude of the conductance depends upon the mobilities of the ions and their number, which latter factor is determined by the degree of dissociation of the substances involved and the solubility of the electrolytes in the system.

Thus if the conductance of the solvent is negligible, as is of course the case with aqueous solutions, the conductance will decrease as we add a concentrated solution of the strong acid HX to a dilute solution of the strong base MOH until we reach the conductance of the salt MX at the resulting concentration. Since the original volume of base is large compared to the amount of acid added, the total volume of the solution remains practically constant so that the number of ions between the electrodes does not change to any great extent. The cause of the decrease in conductance lies in the substitution of the slow-moving X ion for the relatively fast-moving OH ion. Beyond the equivalent point the curve rises again since now we are increasing the number of ions between the electrodes; no longer substituting one ion for another, but introducing two ions, one of which is the fast-moving hydrogen ion. If the acid added is weak a similar decrease in conductance will take place but beyond the equivalent point the curve will remain practically flat, increasing or decreasing slightly depending upon dilution, since, although we are adding the fast-moving hydrogen ion, the number is small in each successive addition.

Systems involving salts and acids, salts and bases, or two salts which alter the above factors may be subjected to this method. Thus if the salt M′X′ be added to the salt MX to form the insoluble salt M′X the conductance remains practically constant up to the equivalent point, any deviation being in the main a combined effect of the slight differences in the mobilities of the X and X′ ions and the slight change in concentration. Beyond the equivalent point the conductance rises again due to the fact that we

[1] Findlay, "Practical Physical Chemistry," 4th ed., Longmans, Green and Co., 1928, p. 175.

are once again adding two ions rather than replacing one by another. If both salts formed are insoluble, we simultaneously remove both ions from the original solution until at the end-point the conductance assumes the low value corresponding to that of a saturated solution of M′X and MX′. Beyond this point the curve, of course, rises again.

A series of titrations such as sodium hydroxide with hydrochloric and with acetic acid, oxalic acid with sodium and with barium hydroxide, magnesium sulfate with sodium and with barium hydroxide, together with the written report, frequently gives the student a far clearer picture of conductance in general, effects of concentration, of strong and weak electrolytes, ionic mobilities,[2] relative solubility and the like, than could usually be expected from such simple experiments.

FIGURE 1.—CONDUCTANCE CELL

A type of cell which has been found convenient for student use is pictured in Figure 1. Such a design permits the titration to be carried out in a large beaker above which a buret can be supported. It has the further advantages of fixed electrodes which are protected from displacement, and freedom from changes in the value of the cell constant due to differences in proximity to the walls of the beaker as the cell is moved during the course of the titration. Indeed, the unit itself may be used to stir the solution.

As the titrations are usually carried out, a few cubic centimeters of solution (10 cc. of 0.5 *N* NaOH, for example) are introduced into the beaker and sufficient water added to more than cover the electrodes. The second substance (0.5 *N* HCl) is then added in small amounts until well past the end-point, readings of the resistance being taken after each addition. The volume of solvent added to the original solution is so large that the subsequent addition of the second substance does not materially affect the total volume. Changes in the degree of dissociation and dilution are thus practically eliminated.

In certain cases in order to obtain greater analytical accuracy, amounts of some other solvent, usually alcohol, have been added to the system. It has seemed[3] that this could be carried farther and titrations developed in non-aqueous solvents in the hope of giving the student a somewhat more generalized viewpoint. Among other things, the freshman sees that a current passes through a solution of hydrochloric acid in water but not

[2] Examples of several types of curves are given by Harned, *J. Am. Chem. Soc.*, 39, 252 (1917).

[3] Kolthoff and Furman, "Volumetric Analysis," Vol. 1, John Wiley and Sons, Inc., **1928,** p. 251. Furman, "Treatise on Physical Chemistry" (Taylor), Van Nostrand, **1924,** p. 854.

through such a solution in toluene; that solutions of cane sugar in water fail to conduct the electric current; and that one group of salts is highly soluble, the salts of another group less so, and that still others are "insoluble." The distinction between electrolytes and non-electrolytes seems to be grasped quite readily. It is by no means a unique experience, however, to be asked by more advanced men whether any substances conduct in other than water solution, nor to encounter a student so imbued with the table of solubilities in this solvent that he fails to realize that substances may be dissolved in other media and go into solution to different extents and in quite different groupings in the various solvents.

While for practical purposes water is the "universal solvent," just as oxygen is the customary basis of combustion, the importance of other systems for broader concepts and progress along theoretical lines is shown by the work of Franklin, Kraus, Schlesinger, Walden, and others.

With these facts in mind, the following experiments involving solutions in methyl and ethyl alcohol are presented. Since the titrations are carried out from the standpoint of the knowledge gained from interpretation of the curves rather than from that of an analytical procedure certain differences from the conditions with aqueous solutions have been made. The concentrations given below are to be looked upon only as approximate. Further experimentation would be necessary to determine the quantitative accuracy of the method when applied to such systems and in any case their applicability would be limited. Because of the difficulty of obtaining non-aqueous solvents which are absolutely pure, in most cases the original substance to be titrated was not further diluted since a small percentage of impurity (usually water) would be of considerable importance when present in a large amount of solvent.[4] In such a case the solubility relationships might be considerably altered. Because of this modification of the usual procedure, the total volume of the system does not remain constant and changes in concentration, which do not enter the titrations in water solutions, must be taken into account in understanding the curves.

The apparatus used in the determinations here recorded consisted of the usual Wheatstone bridge using a hundred centimeter wire and a microphone hummer. The cell, whose constant was about 0.3, was equipped with fixed electrodes but differed from the one described above in that it could be completely closed between additions, thus preventing concentration changes resulting from loss of the solvent through evaporation. No attempt was made to control the temperature, which was about 25°C. A high-grade, commercial absolute methyl alcohol was once redistilled before being used to make up the solutions. Ninety-five per cent ethyl alcohol was allowed to stand over quicklime for about a week, after which time it was distilled for use in the ethyl alcohol solutions. The other

[4] An additional consideration was the relatively high cost of the chemicals used.

chemicals were all of high quality and were dried when necessary but not otherwise purified.

TABLE I

TITRATIONS IN ETHYL ALCOHOL

30 cc. 0.5 *N* HCl Fig. 2:1 Box:40 ohms		10 cc. 0.5 *N* HCl (dild.) Fig. 2:2 Box:118 ohms		30 cc. 0.2 *N* NaI Fig. 3 Box:70 ohms	
Cc. 0.5 *N* NaOH	Bridge reading	Cc. 0.5 *N* NaOH	Bridge reading	Cc. 0.2 *N* $AgNO_3$	Bridge reading
0	49.2	0	49.4	0	48.5
5	44.0	2	46.5	5	43.0
10	38.7	4	41.0	10	37.2
15	32.6	6	35.2	15	31.7
20	25.0	8	29.0	20	26.0
25	15.7	10	19.2	25	20.2
30	5.7	12	18.7	30	15.0
35	13.1	14	25.0	35	15.5
40	18.2	16	29.8	40	17.0
45	21.5	18	34.1	45	18.4
50	24.6	20	37.0	50	19.7
55	26.5			55	20.2

Table I and Figures 2 and 3, where the bridge wire readings are plotted against the number of cubic centimeters of solution added, show the results obtained with solutions in ethyl alcohol. When 0.5 *N* NaOH was added to 30 cc. of 0.5 *N* HCl, precipitation of sodium chloride immediately took place and the conductance dropped continuously due to the removal of the hydrogen ion to form water and the chloride ion to form the insoluble salt. (Curve 1.)

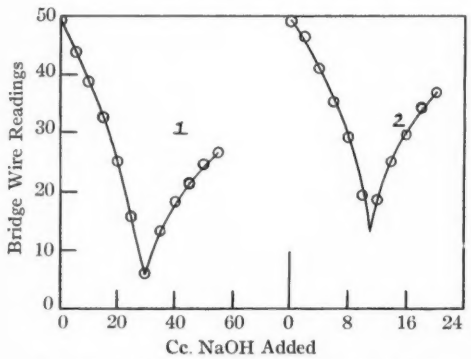

FIGURE 2.—HCL–NAOH TITRATIONS IN ETHYL ALCOHOL

The lowest point on the curve represents the conductance of a saturated solution of sodium chloride in alcohol containing a trace of water (any moisture not completely removed from the alcohol plus that due to the one molecule of water formed simultaneously with each molecule of salt). After neutralization the curve again rose because of the addition of the two ions of the base.

The experiment was repeated, this time adding 50 cc. of anhydrous alcohol to about 10 cc. of the acid solution before starting the titration. Obviously Curves 1 and 2 are of the same general form differing only

slightly because of the dilution. In the second case the curve does not drop to quite such a low point. Even so, the resistance corresponding to the lowest point on the curve is the same as in Curve 1, within the limits of experimental error and the accuracy of extrapolation, since the nature of the medium in which the saturated solution was formed was not materially altered by the dilution.

The data in columns five and six of Table I are plotted in Figure 3. In this case 0.2 N $AgNO_3$ was added to about 30 cc. of 0.2 N NaI and precipitation immediately took place. Although a saturated solution of sodium nitrate in ethyl alcohol (*ca.* 3.3×10^{-3} N) is only about a third as concentrated as one of sodium chloride (*ca.* 8.8×10^{-3} N), the resistance at the minimum in Figure 3 is only about half that in Curves 1 and 2 (Figure 2) indicating that the hydrogen ions are far more effectively removed in the formation of water than are the iodide ions in the formation of silver iodide. Indeed, the precipitation of the silver iodide was perhaps far from complete, although its presence was shown at once by its characteristic color. After the endpoint the conductance increased but little since addition of the dilute precipitant in amount comparable to the total solution, already containing a considerable number of ions, did not greatly change the concentration between the electrodes.

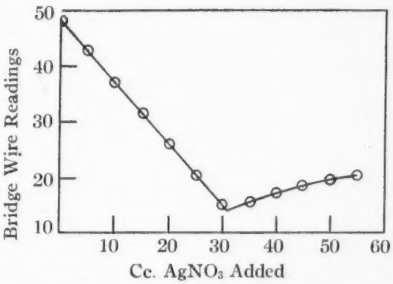

FIGURE 3.—NaI–$AgNO_3$ TITRATION IN ETHYL ALCOHOL

In Table II are given the results of titrations in methyl alcohol. Figure 5 shows the data given in columns 1 and 2 of Table II resulting from the addi-

TABLE II

TITRATIONS IN METHYL ALCOHOL

30 cc. 0.5 N KI Fig. 4 Box:9 ohms		30 cc. 0.2 N KI Fig. 5 Box:22 ohms		30 cc. 0.5 N KI Fig. 6:1 Box:7 ohms		10 cc. 0.5 N KI (dild.) Fig. 6:2 Box:23 ohms	
Cc. 0.5 N NH_4NO_3	Bridge reading	Cc. 0.2 N $AgNO_3$	Bridge reading	Cc. 0.5 N LiCl	Bridge reading	Cc. 0.5 N LiCl	Bridge reading
0	49.5	0	49.5	0	47.5	0	49.0
5	47.5	5	44.0	5	39.5	2	50.0
10	46.0	10	37.5	10	36.0	4	50.5
15	43.5	15	31.0	15	33.5	6	50.5
20	42.0	25	18.7	20	31.5	8	48.0
25	40.5	35	17.0	25	30.0	10	47.8
30	40.3	45	20.0	30	29.0	12	47.7
35	40.5	55	21.4	35	28.0	16	48.2
40	40.8	65	22.0	40	28.0	20	48.7
50	41.2			50	27.8		
60	41.7			60	27.8		

tion of 0.5 N NH_4NO_3 to about 30 cc. of 0.5 N KI. Ammonium iodide is very soluble in methyl alcohol whereas the saturated solution of potassium nitrate is only about 2×10^{-2} N so that the latter was very largely removed from solution. In such a case the contrast between the type of curve resulting from the method here used and as usually carried out with aqueous solutions becomes apparent. Consider the addition of a 0.5 N solution of the substance M′X′ to 10 cc. of 0.5 N MX which before the titration is started has been greatly diluted and assume further that MX′ remains in solution while M′X is completely removed by precipitation. The addition of 10 cc. and finally 20 cc. of the precipitant makes virtually no change in the total volume. The net result of the addition of the first 10 cc. of M′X′ is the substitution of 0.5 N MX′ in place of the original 0.5 N MX. Whether the conductance increases or decreases slightly while this is taking place depends upon the degree of dissociation of the two salts and the differences in the mobilities of the X and X′ ions. Addition of M′X′ beyond the equivalent point causes a rise in the curve since one ion is no longer being substituted for another but two free ions are being added. Consider, on the other hand, the conditions which exist when the original solution of MX is not diluted. Now the total volume no longer remains constant and concentration changes must be taken into account. When we have added 10 cc. of 0.5 N M′X′ to 10 cc. of 0.5 N MX once again we have replaced the MX by MX′ but since the total volume has been doubled, the concentration of the solution between the electrodes has been reduced to only 0.25 N resulting in a decrease in the conductance. Addition of 10 cc. of the 0.5 N M′X′ beyond the equivalent point increases the concentration and causes the curve to rise. The relative increase in the concentration is not so great as in the case of the diluted solution nor is the in-

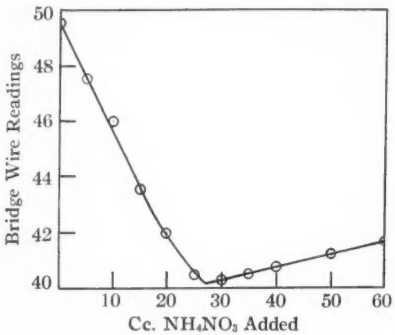

FIGURE 4.—KI–NH_4NO_3 TITRATION IN METHYL ALCOHOL

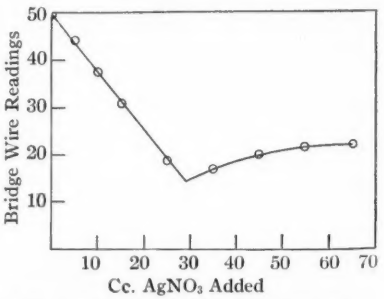

FIGURE 5.—KI–$AgNO_3$ TITRATION IN METHYL ALCOHOL

crease in concentration of the same order as the decrease along the first part of the curve since the addition of the first 10 cc. decreases the concentration to one-half its former value while the second addition increases it from 0.25 N to about 0.33 N.

Figure 5 shows the data given in columns 3 and 4 of Table II resulting from the addition of 0.2 N by $AgNO_3$ to 30 cc. of 0.2 N KI. The interpretation is similar to that given for the titration of silver nitrate and sodium iodide in ethyl alcohol.

Curve 1 of Figure 6 shows the change in conductance when 0.5 N LiCl solution was added to about 30 cc. of 0.5 N KI. Lithium iodide is extremely soluble in methyl alcohol while a saturated solution of potassium chloride is about 6×10^{-2} N. Although precipitation took place immediately, the very appreciable solubility of the chloride may account for the difference in the form of the curve throughout from what would obtain in the case where one of the substances formed were more truly insoluble. The present titration is similar to the case in which ammonium nitrate was added to potassium iodide where likewise complete precipitation failed to take place. More rigid analysis of the curves from the standpoint of the relative changes in the resistance cannot be made because of the fragmentary data for non-aqueous solvents as to such factors as ionic mobility, degree of dissociation, mutual ionic effects, and the like.[5]

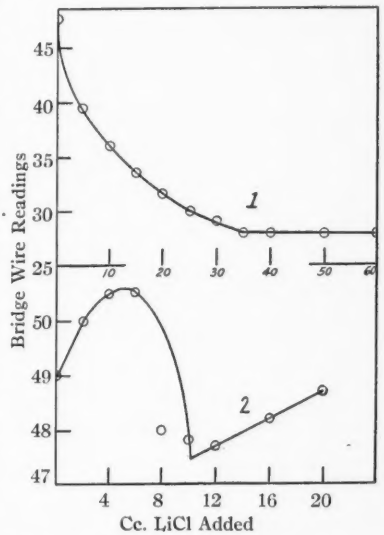

FIGURE 6.—KI-LiCl TITRATIONS IN METHYL ALCOHOL

The effect of partial solubility is shown in the second curve in Figure 6. In this case 10 cc. of the 0.5 N KI was diluted with the anhydrous methyl alcohol to a total volume of about 30 cc. before the 0.5 N LiCl was added. At first no precipitation took place, with a resultant increase in the concentration of ions between the electrodes and a corresponding increase in conductance. Upon further addition of the lithium chloride solution precipitation took place and the conductance decreased from the maximum to

[5] The solubility relationships in water solution for certain of these salt combinations (*e. g.*, silver iodide in solutions of potassium iodide and of silver nitrate) are far from what might be predicted at least at the higher concentrations.

a sharp break, as shown in the Figure 6, beyond which it increased regularly with subsequent additions. That the resistance corresponding to the break in Curve 2 is appreciably higher than that in Curve 1 does not indicate any difference in the two cases in the solubility of the potassium chloride nor in the number of its ions between the electrodes, but merely the greater attenuation of the ions of the lithium iodide in the experiment where the original substance was first diluted.

In the foregoing experiments the interest lies not in a quantitative aspect but in the insight gained from the form of the curves. Even from this qualitative viewpoint many ideas seldom thought about by the undergraduate in this oxygen-water world may be brought to his attention. Certain of his questions, lurking or expressed, may be clarified. The experiments are not suggested as regular exercises for all students of physical chemistry both because of the cost of the chemicals and because of the time-consuming preparation of the solutions. More especially, also, it is felt that the average student will profit more from seeing them performed by one or two members as a group demonstration where the various points involved may be brought out in discussion. When such a demonstration follows the regular titrations in aqueous solutions, benefits may accrue in the form of emphasis upon the requisites for accuracy in the usual quantitative procedure and in a broader outlook and understanding of solutions in general.

THE UNKNOWN TEACHER

I sing the praise of the unknown teacher. Great generals win campaigns, but it is the unknown soldier who wins the war. Famous educators plan new systems of pedagogy, but it is the unknown teacher who delivers and guides the young. He lives in obscurity and contends with hardships. For him no trumpets blare, no chariots wait, no golden decorations are decreed. He keeps watch along the border of darkness and makes the attack on the trenches of ignorance and folly. Patience is his daily duty; he strives to conquer the evil powers which are the enemies of youth. He awakens sleeping spirits. He quickens the indolent, encourages the eager, and steadies the unstable. He communicates his joy in learning, and shares with boys and girls the best treasures of his mind. He lights many candles which, in later years, will shine back to cheer him. This is his reward. No one has deserved better of the republic than the unknown teacher. No one is more worthy to be enrolled in a democratic aristocracy.

—HENRY VAN DYKE

The Term "Rayon." It is of interest to note that the largest manufacturer of artificial silk in Great Britain, Courtlands, Ltd., has decided to abandon the use of the name "artificial silk," and to use the term "rayon" only. "Rayon" is in general use in the United States, and there can be no reason to complain of the replacement of the term "artificial silk," as "rayon" has sufficient characteristics of its own to merit a name which is distinctive and descriptive of a textile fiber which ranks next in importance after cotton and wool.—*Chem. & Ind.*

LECTURE DEMONSTRATION ON HYDROGEN*

C. S. ADAMS, ANTIOCH COLLEGE, YELLOW SPRINGS, OHIO

Lecture demonstrations, particularly in the field of college freshman chemistry, have always played a very important part in chemical education. The early masters were known for their brilliance in demonstrations. And yet, in the recent discussions of chemical education, both in our journals and meetings, the subject has been neglected. The symposium on lecture demonstration, which the Division of Chemical Education held at the Columbus meeting of the American Chemical Society, introduced this very important field for investigation.

It seemed wise to canvass the colleges and universities for information relative to what is being done in the way of freshman chemistry lecture demonstrations. A questionnaire was designed for this purpose and sent out to 290 different colleges and universities. The list of colleges was obtained from the *Bulletin of the American Association of University Professors*. This list included a convenient number and practically all of the larger universities and colleges. The questionnaires were sent out on March 15th. Answers to 144 have been received to date. The answers received include practically all of the larger universities and colleges.

Lecture demonstrations have developed along with our newer ideas on chemistry. Most colleges and universities have developed their own collections of lecture demonstrations. The introduction of the college glass blower has encouraged the development of original and more effective apparatus. Very few of these new demonstrations have been published. The few which have been published are scattered through our journals in such a way as to make them more or less unavailable. The following books give information:

NEWTH, G. S., "Chemical Lecture Experiments," Longmans, Green & Co., 55 Fifth Ave., New York City, **1892.**

HEUMANN, K., "Anletung zum Experimentieren," Friedr. Vieweg & Sohn, Braunschweig, **1893.**

ARENDT, R., "Technik der Experimental Chemie," Voss, Hamburg, **1900.**

BENEDICT, F. G., "Chemical Lecture Experiments," Macmillan Co., 60 Fifth Ave., New York City, **1901.**

DAVISON, H. F., "A Collection of Chemical Lecture Experiments," Chemical Catalog Co., Inc., 419 Fourth Ave., New York City, **1926.** (Good but incomplete.)

SCHIED, K., "Vorbereitungsbuch für den Experimentalunterricht in Chemie," Teubner, Leipzig, **1926.**

The first four books are good but out of date; the latter two are incomplete. Other than these books no organized attempt has been made to obtain

* Presented before the Symposium on "Lecture Experimentation," Division of Chemical Education, at the 77th Meeting of the American Chemical Society, Columbus, Ohio, April 29 to May 3, 1929. For other papers see THIS JOURNAL, **6**, 1882–915 (Nov., 1929).

this information from various colleges and correlate it for use in various courses in chemistry.

The questionnaire was divided into two parts: (1) General. *The object was to get the attitude of colleges and universities on the value of lecture demonstrations and conditions under which they are given.* The answers to this part also helped us to better evaluate the latter part. (2) Hydrogen. *The object was to find out what experiments are being used in lecture demonstrations on hydrogen.*

The author wishes to state here that there is no claim that the questionnaire sent out was complete or even adequate. In fact, the results indicate that it ought to be revamped if this method of investigating the subject is continued. It is even a question whether better results could not be obtained by a different method of approach. If the questionnaire helps to open up and stimulate interest in the field of lecture experiments, it will have accomplished its objective.

The following data have been tabulated from the answers to these questionnaires. Since in many instances questions were not answered or the answers did not permit of classification, it is impossible to give complete data.

Questionnaire. I. General

1. *Name of college or university.* 144 answers to questionnaire received.

2. *Number of lecturers in freshman chemistry.*

Number of lecturers	Number of colleges
1	78
2	50
3	2

3 (*a*). *Length of lecture period.*

Length of lecture period	Number of colleges
25 minutes	1
One hour	135
Two hours	1

(*b*). *Number of lectures in course.*

For those with high-school chemistry, average	40
For those without high-school chemistry, average	110

4. *Approximate number of students in room during lecture.*

Number of students	Number of colleges
1–50	61
51–100	37
101–150	23
150–	24

5. *Do you give lecture demonstrations in freshman chemistry?*

Number of colleges answering "yes"	114
Number of colleges answering "no"	4
Number of colleges answering "limited number"	15

6. *In general what fraction of the lecture period is actually devoted to demonstrations?*

Average between one-quarter and one-half depending on nature of subject. 5 schools answered "none." Varies greatly.

7 (*a*). *In general do you believe that demonstrations should be short (not over 5 minutes)?*

Schools answering "yes"	99
Schools answering "no"	17
Schools answering "varies"	2

The comments on this question were very interesting. There was an almost unanimous agreement that experiments should be short, simple, pertinent, and decisive.

(*b*). *In general do you believe in simple demonstrations?*

Schools answering "yes"	96
Schools answering "no"	10
Schools answering "reasonably"	2

(*c*). *In general do you believe in speed in execution of experiments?*

Schools answering "yes"	64
Schools answering "no"	5
Schools answering "workable"	9

8. *Do you avoid the use of demonstrations in which explosions occur or poisonous fumes are evolved?*

Yes	42
No	42
Where possible	17
Not necessarily	17
Avoid fumes only	8
Avoid explosions only	2

9. *Do you make a distinction in the list of lecture demonstrations given before those who have had and those who have not had high-school chemistry?*

Yes	38
No	84
Some	6

10 (*a*). *Do you supplement your lectures with lantern slides?*

Yes	61
No	61
Use motion pictures	6
Do not use slides, but would like to or are going to, etc	4

(*b*). *If so, in how many of the total number of lectures in freshman chemistry do you use slides?*

Varies. Depends upon subject considered.

11. *In general do you believe in the inclusion of demonstrations of historical significance?*

Yes	39
No	36
A few	24
Normal*	17

*"Normal" includes those who said "only if experiment has practical value aside from historical value," etc.

12. *State briefly your own feeling as to the value of lecture demonstrations.*

The comments on this question were as interesting as they were varied. In general there was an agreement that lecture experiments were invaluable when used to explain and illustrate the subject but useless and even harmful when presented as "stunts" or "shows." In fairness to a minority opinion expressed in answer to this question, it should be stated that this group believes lecture experiments and lectures are a by-product of wholesale education. Under ideal conditions for teaching chemistry, this group would do away with both lectures and lecture experiments. The author hopes to present a separate article on the comments to this question.

Questionnaire. II. Hydrogen

1. *State the number of lectures devoted to hydrogen.*

No. of lectures devoted to H_2	$\frac{1}{2}$	1	1–2	1–3	2	2–3	2–4	3	3–4	4	4–5	5	Varies
No. of colleges	3	28	11	1	45	14	1	13	1	1	1	1	2

2. *Is the subject of hydrogen taken up near the beginning of the course?*

Yes	95
No	5

3. *Do you use lantern slides?*

Yes	7
No	100
Would like to, but don't	6
Use motion pictures	3

Motion pictures used were: Industrial uses of hydrogen and acetylene; electrolysis of water; historical and industrial.

4. *Please list the lecture demonstrations which you give on hydrogen to your freshman chemistry classes.*

(*a*). *Preparation of hydrogen.* The following experiments are the conventional ones unless otherwise stated.

Experiment	Schools demonstrating
(*1*) *Electrolysis*	79
(*2*) *Metals and non-metals on water*	
a. $Na + H_2O$	95
b. $K + H_2O$	25
c. $Ca + H_2O$	34
d. $Mg + H_2O$	30
e. $Fe + H_2O$	54
f. $C + H_2O$	2
g. Hydrone	3
(*3*) *Metals on acids*	
a. Zn, *b.* Mg, *c.* Al, *d.* Fe + HCl or H_2SO_4	83, 64, 56, 32
e. $Na + HCl$	1
f. Zn + various acids	12
g. $Cu + HCl$	4
h. $Pb + HCl$	1
(*4*) *Metals on bases*	
a. $Zn + NaOH$	28
b. $Al + NaOH$	25
c. $Zn + NaOH$	4 (fused in crucible)

(5) *Miscellaneous*

a.	Recovery from water gas	1
b.	Si + NaOH	3

(*b*). *Properties of hydrogen.*

(*1*) *Physical*

a.	Taste, odor, color, solubility	59
b.	Density	67
c.	Diffusibility	61
d.	Soap bubbles	32
e.	Catalytic ignition by platinum black	13
f.	Effect of inhaling H_2 on voice	2
g.	Adsorption in platinum or palladium	18
h.	Contraction in volume of $2H_2 + O_2 \longrightarrow 2H_2O$ (steam)	1

(2) *Chemical*

a.	Combustion of H_2	93
b.	Explosiveness	80
c.	Reducing action: $CuO + H_2$	64
d.	$Zn + H_2 + KMnO_4$ (nascent H_2)	4
e.	$H_2 + Cl_2$	6
f.	Hydrogen siren or singing flame	1
g.	Sodium amalgam	1
h.	$H_2 + S$	1
i.	$HgO + H_2$	1
j.	$Fe_3O_4 + H_2$	1
k.	Atomic hydrogen	1

(*c*). *Uses of hydrogen.*

a.	Blast torch	48
b.	Atomic H_2 blast torch	4
c.	Hydrogenation of fats	44
d.	Balloons	11
e.	$CO + 2H_2 \longrightarrow$ methanol	2
f.	Use: making NH_3	1
g.	Oxyhydrogen welding outfit	1
h.	Municipal gas	1

Colleges for whom no experiments are listed or indefinite answers given.

Usual experiments only	15
No experiments	13
Do not teach elementary chemistry	2
Did not answer questions on hydrogen	7
Are experimenting with course	1
None as a rule	1
Do not treat hydrogen this way	3

Conclusions

1. The answers to the questionnaires indicate a very definite feeling in favor of lecture demonstrations in freshman chemistry. There were a few colleges who did not give lecture demonstrations but would if facilities

permitted. A few doubted the value of any demonstrations not performed by the student himself.

2. The author hoped that many new experiments and original ways of presenting older experiments would be found in the answers received. In this the results were somewhat disappointing, indicating that colleges, in general, present the conventional list of experiments illustrated in the usual college textbook. There were a few experiments and modified apparatus suggested which will be described in a later paper. The nature of the subject might easily account for the dearth of new demonstrations. A subject such as "The Gas Laws" would undoubtedly bring in many new types of apparatus.

3. Opinion was almost unanimous in that lecture experiments should be short, simple, pertinent, and decisive to be effective. In general, lecture experiments should not duplicate the laboratory experiments.

4. The questionnaire sent out revealed certain weaknesses which should be corrected in any future attempt to secure similar information. It was too long to get the details necessary for proper analysis. A few of the questions were not clear, resulting in ambiguous and indefinite answers.

5. Whether the questionnaire method is the proper way of obtaining information on lecture demonstrations or whether some other method is preferable, the author feels that such information ought to be collected and made available through THIS JOURNAL.

Greenest Plants Grow Most Efficiently. Plants whose leaves contain the most chlorophyll, the stuff that makes leaves green, are the most efficient at the business of making new plant tissue—which is, from the farmer's point of view, the chief end and object of plant existence.

Ever since pioneer plant physiologists found out what chlorophyll is, and learned that its function is to capture carbon dioxide out of the air and with the help of sunlight to combine it with water to make sugar, it has been taken for granted that the more chlorophyll a plant has per square inch of leaf surface the faster it can make new stems and leaves.

It has remained for Dr. H. B. Sprague and Dr. J. W. Shive of the New Jersey Agricultural Experiment Station to determine the relation accurately, using the exact analytical methods of the chemical laboratory. They have recently reported their results in detail to the American Society of Plant Physiologists.

They grew standardized breeds of corn under carefully controlled conditions. They supplied nutrient chemicals at a known rate. They measured the areas of leaves, extracted the chlorophyll and determined its quantity per square centimeter, and weighed their plants as they harvested them.

Correlating their data, they found that the strains with the most chlorophyll per unit area had produced the most cornstalk in a given time. They also found that the plants which produced the greatest spread of leaves were most efficient at the business of growth. A yellow pigment, carotin, which is found in leaves, bore a similar relation to the rate of new stalk and leaf production as did the chlorophyll.—*Science Service*

THE PROBLEM OF PROBLEMS IN HIGH-SCHOOL CHEMISTRY

PAUL K. WINTER, WASHINGTON HIGH SCHOOL, UTICA, OHIO

If all the students in beginning courses in chemistry were mathematicians, the average chemistry teacher would have a much easier task. Many students with little or no foundation in algebra find their way into classes in chemistry. Obviously, the course must then be made largely "descriptive" or else a means of presenting chemical mathematics in an extremely simple form must be devised, since there is never time to go back and secure the groundwork in algebra that is desired. This places the conscientious teacher in a difficult position.

I am quite convinced of two things—that any method of science teaching which neglects the mathematical side is not scientific (that was Lord Kelvin's idea, too) and that most of the essential problems that appear in beginning courses in chemistry can be reduced to a few type forms which do not require any great amount of mathematical ability. It is my purpose here to present, without any special claim to originality, some methods which I have found useful in simplifying a few of my students' difficulties.

Usually one class period is sufficient time to polish up a few of the tools which the student has almost forgotten—the equations of algebra, the half-dozen or so of axioms of elementary algebra and geometry, and the laws of proportion. A few minutes, early in the course, may well be spent in discussing the metric system and its advantages. This brief review of fundamentals is well worth the time it takes.

High-school students meeting the gas laws of Boyle and of Charles for the first time are always more or less bewildered. I have found the following device useful in showing that in a system of three dependent variables, one factor cannot vary without effecting a change in at least one other. Take a meter stick and call each end and the middle the three variables. Then hold the middle of the stick stationary and show that both ends must move if one of them does, or either end may be held stationary and the other end cannot be moved without moving the middle. Finally, show that all three variables may change simultaneously, and each either up or down. The illustration may be further applied directly to the gas laws by calling the ends *Pressure* and *Volume*, respectively, and the center, *Temperature*. Since in Boyle's Law the temperature must remain constant, hold the center stationary and observe that if P is raised, V is lowered—inverse variation of P and V with T constant. In Charles' Law P is constant, so hold that end still and observe that as T rises, V also rises—direct variation of V and T with P constant. And if the point called V is held still, P and T move up or down together—direct variation with V constant.

The above demonstration takes but a few minutes and even the least mathematically minded members of the class can see reason in what might easily be mere words; and a way is opened up for a mathematical statement of the problem.

Most high-school texts will develop the gas law equations and leave the student with three formulas to remember. I have found it advantageous to combine them into one formula which applies in all cases. But there are always some students who object to having the formula, $PVT' = P'V'T$, thrust upon them bodily: they want to know why it is so. Some of them are satisfied by seeing it developed in the following manner: since T varies jointly with P and V, it varies as their product, *i. e.*,

$$T:T' :: PV:P'V'; \quad \text{whence } PVT' = P'V'T.$$

Those to whom joint variations remains a mystery are usually placated in another way. Write the three formulas thus, and apply the axiom of multiplication:

$$\begin{array}{ll} \text{Boyle's Law,} & PV = P'V' \\ \text{Charles' Law} & \begin{cases} PT' = P'T \\ VT' = V'T \end{cases} \end{array}$$

$(PVT')^2 = (P'V'T)^2$; whence, by applying another axiom, we have $PVT' = P'V'T$

The practicality of the formula becomes evident when it is pointed out that it becomes the formula of Boyle's Law by making T constant, and of Charles' Law by making P or V constant. A few exercises in making correct substitutions in the formula soon make the application of the gas laws clear.

Similar methods for clarifying other types of chemical calculations can be readily developed, and are well worth the time and effort that they require. Most of the problems that the beginning student will meet can be readily solved by applying the laws of proportion; and I am of the opinion that there will be less confusion if the problems are all approached in as nearly the same manner as possible. A few examples will show how a number of different problems can be reduced to one type which can be solved in four main steps which are always the same. These steps are: (1) form an equation which states the fundamental fact given or implied in the problem, (2) form a similar equation with X in the place of the quantity sought, (3) form a proportion involving the four quantities concerned, and (4) solve the resulting algebraic equation. The following examples will illustrate what I mean.

(*a*) Find the weight of 50 liters of oxygen measured under standard conditions.

(1) 1 liter O_2 = 1.429 g.
(2) 50 liters O_2 = X g.
(3) $1:50::1.429:X$
(4) $X = 50 \times 1.429 = 71.45$ g.

(*b*) Find the volume occupied by 73 grams of hydrogen under standard conditions.

(1) 1 liter H_2 = 0.08987 g.
(2) X liters H_2 = 73 g.
(3) $1:X::0.08987:73$
(4) $0.08987X = 73$

$X = 812 +$ liters

(*c*). What weight of $KClO_3$ is required to produce 12 grams of oxygen? From the percentage composition of $KClO_3$,

(1) 100 g. $KClO_3 \equiv 39.2$ g. O_2 (3) $100:X :: 39.2:12$
(2) X g. $KClO_3 \equiv 12$ g. O_2 (4) $39.2X = 1200$

$$X = 30.6 \text{ g.}$$

(*d*). What volume of hydrogen can be prepared by the reaction of 10 grams of zinc with hydrochloric acid? What weight of hydrogen? From the equation, $Zn + 2HCl \longrightarrow ZnCl_2 + H_2$,

(1) 65.37 g. $Zn \equiv 22.4$ liters (2 g.) of H_2 (3) $65.37:10 :: 22.4:X\ (2:Y)$
(2) 10 g. $Zn \equiv X$ liters (Y g.) of H_2 (4) $65.37X = 224 \quad 65.37Y = 20$

$$X = 3.43 \text{ liters} \quad Y = 0.306 \text{ g.}$$

(*e*). How many cubic centimeters of $N/4$ HCl will just react with 10 grams of $NaHCO_3$?
From the equation, $HCl + NaHCO_3 \longrightarrow NaCl + H_2O + CO_2$,

(1) 1000 cc. $N/4$ HCl $\equiv$ 84/4 or 21 g. $NaHCO_3$ (3) $1000:X :: 21:10$
(2) X cc. $N/4$ HCl $\equiv$ 10 g. $NaHCO_3$ (4) $21X = 10{,}000$

$$X = 476 + \text{cc.}$$

The number of examples that might be given is unlimited. The chief advantage that I can see in this method is the uniformity of procedure, whether the problem deals in grams, mols, volumes, or normalities, so that the inexperienced student can always know how to start. I have tried the plan with good success in my classes, and I would welcome any criticisms or suggestions from any readers of THIS JOURNAL, on how to simplify further one of the hardest spots in teaching chemistry in high schools.

Turquoise Mined in Prehistoric California. Extensive mining operations were carried on near Victoriville, California, many centuries ago, M. J. Rogers, who has recently completed a study of the mines in the Mohave Sink area for the San Diego museum, has discovered.

There are indications of over two hundred mines in this region which Mr. Rogers believes were abandoned many centuries ago. The material mined was the semi-precious stone turquoise, which was so extensively used in prehistoric times by the Indians in Arizona, New Mexico, Mexico, Yucatan, Peru, and Chile, where it was employed in mosaic inlay. The shields and masks from prehistoric times in Mexico are the finest examples of inlay mosaics known from the western hemisphere.

The prehistoric mines were all of the open-pit type excavated through solid rock, by primitive stone tools still found near the mines, to a depth of six or eight feet. During the centuries since the mines were abandoned the pits have filled with loose rock and sand, thus preserving these ancient workings from destruction.

There is evidence to show that the early Pueblans from eastern areas operated the mines, and it seems probable that they were abandoned because of the distance from water, which today is only to be had during part of the year at a distance of several miles.—*Science Service*

SOME UNUSUAL STUDENT PROJECTS

ORVILLE S. WALTERS, GARBER, OKLAHOMA

Toilet Preparations

In nearly all high-school chemistry groups there are students who are planning to pursue either medicine or pharmacy. A number of novel projects suggest themselves which will prove very interesting to these students and others as well. One such group of projects is that of making pharmaceutical preparations on a limited scale. The "Scientific American Cyclopedia of Formulas" is a valuable guide in preparing many of the simpler articles. Under "Toilet Preparations" may be found formulas and procedure for making a large variety of staple drug-store commodities. Some of these which have been successfully prepared by students are cold creams of various types, shampoos, hair tonics, mouth washes, hair oil, Listerine, smelling salts, toilet water, and tooth powder. The simplicity of such preparations is nearly always a surprise to the student. Almost no apparatus is required, and the ingredients can usually be obtained at a well-stocked drug store.

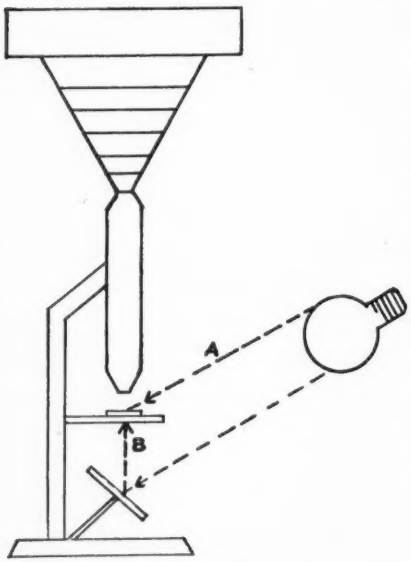

FIGURE 1

Patent Medicines

The patent medicine traffic is deserving of student investigation. The amazing composition of many common nostrums is generally a revelation. It is frequently possible for the student to duplicate these proprietary remedies, particularly in cases where their composition is simple. "Nostrums and Quackery" in two volumes, published by the American Medical Association (Chicago) gives the ingredients of a large number of such preparations, as do also the reports of the American Medical Association's chemical laboratory. Some projects which may be worked out are: the duplication of common patent medicines, with comparative cost of the genuine and its imitation; the making of posters bearing original packages and calling attention to exaggerations; the making of panels bearing advertisements from current publications, showing false claims of remedies, and accompanied by reported analyses; the analysis in laboratory of the

alcoholic content of patent medicines. A large number of patent medicines adapt themselves quite readily to duplication in the average laboratory. Among these may be mentioned the following well-known names: Absorbine, Jr., Sloan's Liniment, Orchard White, Othine, Freezone, Vick's Vap-O-Rub, Mentholatum, Dr. Miles' Nervine, Sal Hepatica, Pluto Water, Mum, Canthrox, and Danderine, all of which will be found described fully in "Nostrums and Quackery."

FIGURE 2.—SAND GRAINS FROM HIGHER LEVEL OF AN OIL WELL

Photography

The study of photography always affords as a project the technic of developing and printing negatives. However, the interest of this may be enhanced by providing novel subjects for picture-taking.

Subjects. A few of these may be mentioned, though some of them are fairly well known. Moonlight pictures, made by long exposures, one to seven hours in length; outdoor pictures taken by flood- or arc-lights, also made by long exposures; silhouettes made by flashlight; photographs taken directly upon a piece of sensitive paper by longer exposure; successive photographs of the moon on the same film to show movement; pictures of lightning made by opening camera during a night thunderstorm until a brilliant flash; the making of double exposures showing a person or object twice in the same picture by covering one side of the lens while the first exposure is made, then the other half of the lens for exposing the corresponding side of the negative. "Kodakery" and the various pamphlets distributed by Eastman Kodak Co., suggest many more out-of-the-ordinary uses for a camera.

FIGURE 3.—SAND GRAINS FROM LOWER LEVEL OF AN OIL WELL

"*Spirit-photographs*" attracted considerable attention a few years ago. These were usually ordinary portraits in which one or more "spirit" faces had been caused to appear. This may be readily accomplished by the amateur. The "spirit" face may be taken on the negative first, after which the actual portrait is made, or, better still, the "spirit" face or faces may be printed on the sensitive paper from their negatives, the portrait then being printed

over it from another negative. Or, one negative or portion of film may be superimposed upon another in a single printing with the same effect. An interesting chapter on this subject, accompanied by several illustrations, may be found in H. Carrington's "The Physical Phenomena of Spiritualism" (Small, Maynard).

Printing. A few unusual devices may be used in the printing of pictures. The use of odd-shaped masks can be endlessly varied to give different margins. Pictures can be given a striking canvas effect by placing a thin handkerchief or cloth between the negative and the glass of the printing frame. A simple method by which the amateur may retouch is to make a negative of the print by treating it with a thin oil to give transparency, retouching to taste with crayon, then using this "negative" as any other in printing.

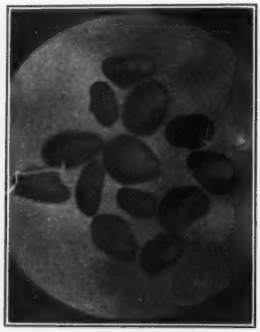

FIGURE 4.—SAND GRAINS FROM LOWER LEVEL OF AN OIL WELL

Photomicrography on a small scale may be performed by the novice in an extremely simple way. The microscope is focused in the usual way and the lens of the camera is applied to the eyepiece, the camera focus being set at "infinity." With a 100-watt frosted bulb and reflector as illumination, placed at a distance of six inches from the stage of the microscope, an exposure of twenty-five to fifty seconds with a diaphragm aperture of sixteen is given. This method affords an interesting procedure for the study of crystals. The accompanying photographs were made through a fifteen-dollar microscope magnifying thirty times (Figure 1). The objects shown are grains of sand from two different levels in an oil well. For light crystals against a dark background (Figure 3) a thin piece of red paper is interposed at *B* (Figure 1). For dark crystals against a light background (Figure 4), the shade is placed in position *A* (Figure 1).

Iceberg Detection. Howard T. Barnes of McGill University, Montreal, Canada, reports that one of the interesting results of the Van Horne expedition just returned from iceberg study on the Atlantic was obtained with the submarine microphone detector. Very loud deep noises were heard three miles from an iceberg and became faint at six miles.

These noises are apparently due to the cracking under water of the iceberg, and they could readily be heard above the usual ship's noises. The succession of cracks was irregular, running from 11 to 68 a minute. The effect is so characteristic that it is proposed to extend the investigation in the hope of finding a method of iceberg detection.—*Nature*

ANALYSIS IN FIRST-YEAR CHEMISTRY*

G. T. Franklin, Lane Technical High School, Chicago, Illinois

The discussions of this paper are intended to apply to first-year chemistry of schools of secondary character. It is largely a matter of the outgrowth of the experience of the writer in teaching chemistry in schools of this character. One of such experience is frequently reminded of the difficulties in the way of the slow student and the superficiality of the quicker witted ones. General notions develop with much slowness. The patience of the teacher is frequently lost in the attempt to get him to understand the nature of a "test." Such simple ideas as indicator tests for acid or alkali are only understood after considerable experience in the use of the indicator. Beads of a few highly colored metallic salts are made. If his knowledge goes no further, he has acquired some information. If he is given a salt whose identity is unknown, and makes it into a borax bead, and it matches one he has previously made, he has improved his knowledge. If he is given one that does not yield any color in the bead, he is puzzled. One feels instinctively that considerable experimenting of a varied character is necessary for him to understand the nature of the test. After the pupils have completed preliminary tests with borax beads and blowpipe with cobalt nitrate, it is the custom of the writer to give unknowns with instructions that they can be found by one of the two methods. The reactions to negative tests are appreciated more by the teacher than by the pupil, but it seems necessary to do such work. Another case of this kind may make the point of view plainer. The pupil is asked to shake thoroughly a mixture of water and table salt until the water is saturated. The solution is then poured off from any undissolved crystals and heated to boiling. A few more crystals are added. He is asked to write his observation and make a conclusion. In spite of the fact that he has been instructed by experiment concerning the meaning of "saturated" and "unsaturated" solutions, his answers are often without meaning. The numbers that fail to get the idea are alarmingly large. There is a suggestion that more work involving the thinking processes is needed covering a larger period of the pupil's activities.

Textbooks of a scientific nature invariably give information and then ask that the information be used in the solution of problems. The value of the information is rated on the basis as to whether the student can use it in solving the problems. Are our laboratory instructions dodging this matter? I think most of us agree that the laboratory is the heart of the subject. To emphasize heavily other aspects of the subject leads to a dangerous field of a sort of "pseudoscience," the cultural value of which might be better obtained in other fields. Analysis has long been recognized as the logical basis for problems in laboratory. It is quite true that

* Condensed and adapted from a paper read before the Division of Chemical Education of the Chicago Section of the American Chemical Society, September 28, 1928.

most courses include much work of the nature of analysis; however, it is largely of a preliminary nature and informational rather than of the problem type. The pupil habitually puts together chemicals that produce reactions, often of a striking character. He is told that certain ones represent tests for ions. If he happens to do the work poorly, he sees the work done by his neighbor, takes note of it, and goes on. The laboratory is altogether a place of information gathering, a place to confirm what has been read in the books or may be at the wish of the pupil. It is rarely called to the attention of the pupil that the laboratory may be used as a means to solve problems. His work is too "socialized." A method of giving each pupil a problem independent of his neighbors should have its place. It must by its nature be more or less supplementary to the usual courses.

To provide needed supplementary work, the writer has devised and adopted for his classes various short schemes. A scheme for the analysis of baking powders is described in a recent issue of *School Science and Mathematics*.[1] Another scheme, which has been under process of development for some time, is discussed in the paragraphs following.

Toward the end of the year there is a need felt for a review of a laboratory nature. The courses generally provide for standard tests for such ions as chloride, bromide, sulfate, etc. To give a pupil an unknown involving one of these ions and ask him to test for an answer until he finds it is a questionable thing to do. It is rather unreasonable to ask him to detect nitrate by the usual test when his unknown may be an iodide or bromide. It is likewise expecting him to do too much to determine the halogens by the use of sulfuric acid alone. Worst of all, he is working without any special plan, unless it is provided by special instructions. The following scheme has been devised to meet this need.

Analysis Involving Some Acid Ions

A. One of the following ions is included in the problem: Cl^- ( ), PO_4^{---} ( ), Br^- ( ), SO_4^{--} ( ), I^- ( ), S^{--} ( ), SO_3^{--} ( ), NO_3^- ( ), CO_3^{--} ( ), BO_3^{---} ( ). Insert the number of the experiment which discusses the respective test in the parentheses following the ion formula.

B. I. Cover a portion of the unknown with concentrated sulfuric acid. Record your observation and then proceed to the next.

II. Make a water solution of a portion of the unknown, filtering off any undissolved residue. Add silver nitrate solution to a portion of the filtrate. A precipitate, insoluble in nitric acid, indicates Cl^-, Br^-, or I^-. A precipitate, white and soluble in nitric acid, may be regarded as negative. A

[1] "A Simple, Practical Problem in Analysis," G. T. Franklin, **29**, 414–8 (April, 1929).

precipitate, not white and soluble in nitric acid, is a test for one of the ions listed above.

III. Make a nitrate test, using a small portion of the filtrate prepared in (II). A colored ring indicates NO_3^-, I^-, or Br^-. Determine by other tests which it is.

IV. Make tests for SO_4^{--}, PO_4^{---}, and BO_3^{---}, using separate portions of the filtrate prepared in (II). Part *A* must be used to confirm your test in (I), (II), (III) in case (IV) is negative.

NOTE: Chemicals often contain traces of chloride and sulfate as impurities. Unless tests for these ions are decidedly positive the result should be merely held in mind for further evidence. Metallic sulfites invariably contain sufficient sulfate to yield a good sulfate test. Sulfur dioxide may cloud limewater as well as carbon dioxide. Do not be satisfied with a probable result. If at the conclusion of the analysis you have obtained positive tests for more than one ion, repeat the tests for these ions. If you are still unable to decide, include all in your report as indicated below.

V. Make a detailed outline of your report as follows:

REAGENT	RESULT	CONCLUSION (List ion indicated present by positive test or ions indicated absent by negative test)
I		
II		
III		
IV		
Special Test		

It is my custom to include in part *A* of the notes the number of the experiment which has given the pupil preliminary information about the test. In case loose-leaf notes are used and not returned to the pupils, the numbers could not be used unless books were available, in which case it would provide a very valuable exercise for the pupils to do it. It would not be a bad idea to have the pupils write out and have available standard tests for use while doing the experiment, repeating those forgotten, before beginning the analysis. Too much emphasis cannot be placed upon requiring the pupil to refer to and do the special test for the ion indicated present in I, II, or III. He will necessarily have to look up the tests included in IV. To the pupil the correct answer assumes too much value and how he solves the problem is kept in the background. It is the business of the teacher to bring the background to the foreground.

A container for each substance used to provide unknowns is kept as part of permanent equipment. It is sometimes necessary to camouflage with other substances that do not interfere with the tests to prevent match-

ing colors. If time and space afford, a large number of containers would be the ideal.

As to how the scheme works out, suppose a pupil is given a bromide. He adds sulfuric acid as directed and may or may not recognize bromine vapors formed. He may write "fuming" or "colored" vapors or both, or "bromine indicated," depending upon how much he remembers. He then proceeds to the next and adds silver nitrate after making a solution, followed by nitric acid. He then writes "Cl^-, Br^-, or I^- indicated." He then makes a test for nitrate ion by the usual method. He records "colored ring," "indicates NO_3^-, Br^-, or I^-." If he is thinking, he will observe that chloride ion is eliminated. He now proceeds to the end of the experiment, obtaining negative results for the remainder. He now looks up the experiment in which Br^- and I^- are discussed, in case he has forgotten, and proceeds with chlorine water and chloroform to confirm his observations. If he receives a sulfate compound, he is not so interested, especially if it is a rather insoluble one like calcium sulfate. It tests his patience and willingness to work without obtaining any clue until near the end.

An interesting side-light to the study is the pupil's reactions to the tests. Often he is imbued with the idea that one test for an ion is final and unimpeachable. It is a warning not to drill too hard on these tests during the preliminary work and leave the pupil to formulate his idea of the test through the analytical study.

How Men Learn Probed by Cornell Experiments. How the human brain learns not to do things, which is as important a branch of education for life as learning to do other things, has been probed by experiments conducted at Cornell University by Dr. A. L. Winsor of the Royal Education Department.

Using the procedure of collecting saliva, which the Russian physiologist, Prof. I. P. Pavlov, first used to show that a dog's mouth will water more freely when it hears a bell and associates the sound with eating, Dr. Winsor placed food before a hungry man and measured the increased flow of saliva which the sight of food caused. When the man continued to look at the food and was given no chance to eat, the saliva flow diminished. The brain had recognized that the food signal was false.

The same negative learning process occurs when a child jumps at the sound of a nearby train whistle. After hearing the whistle many times, instead of jumping more intensively his muscles no longer respond to the shrieking noise. The alarming sound is recognized as boding no harm.

From a series of experiments, Dr. Winsor concludes that psychologists have heretofore underrated the significance of the negative learning process. The law of learning assumes that repeated stimulation of the eye, ear, nerves, or glands will cause a response to become more firmly fixed. Yet repetition in many circumstances serves to decrease or inhibit the response, so that a habit is formed but it is the opposite of what would ordinarily be expected.

Whether an individual develops a positive or negative habit in responding to a situation depends on the biological significance of the situation, Dr. Winsor's experiments indicate.—*Science Service*

QUANTITATIVE ANALYSIS FOR MEDICAL STUDENTS*

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It is frequently argued that standardized courses teach fundamentals as well as specialized ones, but there is little question that the instructor who succeeds in arousing the interest of his students, and in showing them how they may some day be able to use the information he imparts, secures better and more permanent results. Whenever they feel that they have been saddled with a course entirely foreign to their interests, and which can never be of any practical use to them, work becomes half-hearted, and they become more interested in merely passing the course than in permanently acquiring knowledge or skill.

For a number of years I have been giving a course in quantitative analysis for pre-medical students and have frequently been put on the defensive because the men did not expect to analyze many iron or manganese ores after they became practicing physicians! With this in mind, I set out to evolve a new course which should illustrate fundamental principles just as effectively as the old conventional one, with material which would interest the student enough to secure his complete coöperation. The students themselves, upon being consulted, expressed unanimous preference for the new regime.

The old course included three gravimetric methods, chlorides, sulfates, and iron; the calibration of a buret; and eight volumetric methods, Mohr's method for chlorides, soda ash, an organic acid, protein in flour, dichromate method for iron in ore, manganese dioxide in pyrolusite, manganese in iron ore, and free chlorine in bleaching powder. The latter method was unsatisfactory because of instability of the samples. In fact, none of the samples were very satisfactory on account of the labor involved in grinding, mixing, and analyzing them.

The trend in clinical medicine is to avoid gravimetric methods and the use of the analytical balance as much as possible; hence it was decided to give only one gravimetric method, the determination of inorganic sulfates by precipitation as $BaSO_4$, which is still employed in physiological work. One duplicate is filtered through paper and ignited in an ordinary crucible, while the other is filtered through a Gooch, and dried in an oven.

The calibration of a pipet has been substituted for the calibration of a buret, because many spent an unreasonably long time at the latter. The mark is changed if necessary, and the flask then calibrated by delivering ten pipetfuls into it.

The growing importance of colorimetric and micro methods in medical work is recognized by the introduction of Nessler's colorimetric method for ammonia. A simple, reliable procedure for this has been worked out and will be presented later.

* Presented before the Division of Chemical Education of the A. C. S. at Minneapolis, Minnesota, September 12, 1929.

As an example of a volumetric precipitation method, they may run either Mohr's or Volhard's method for chlorides, standardizing the silver solution against NaCl.

For neutralization methods, an HCl solution is standardized against Na_2CO_3; and a NaOH (carbonate-free) solution is prepared by diluting a concentrated NaOH solution (in which Na_2CO_3 is insoluble), and standardized against the HCl. They are then used to determine an organic acid, protein in flour, and inorganic phosphates.

For oxidation-reduction methods, a permanganate solution is standardized against sodium oxalate, and used to determine calcium. Sodium thiosulfate is standardized against potassium dichromate in acidified potassium iodide solution; iodine solution is standardized against the thiosulfate or against arsenious oxide; and the two are used to determine formaldehyde in formalin. Finally, a bromate-bromide solution is prepared and standardized by weighing a definite amount and making up to the mark in the volumetric flask. Then it and the thiosulfate are used to determine the phenol in a phenol solution. All except the flour, organic acid, and chloride samples are delivered in liquid form; and the students analyze aliquot portions.

If desired, the stock sample solutions can be prepared in such a way that the mass delivered can be calculated by multiplying the volume by some simple integer. The students still get enough use of the balance in standardizing solutions, but all congestion is relieved. With the liquid samples, administrative work is greatly simplified, and grading is more certain.

In this new course, no work is given, which is not applicable to medical clinical work, yet fundamental principles have not been slighted.

UNITED STATES CIVIL-SERVICE EXAMINATIONS

The United States Civil-Service Commission announces open competitive examinations for ASSOCIATE AGRONOMIST (Sugar Beets), $3200 to $3700 a year and ASSISTANT AGRONOMIST (Sugar Beets), $2600 to $3100 a year. Applications must be on file with the Civil-Service Commission at Washington, D. C., not later than February 12th.

The examinations are to fill vacancies occurring in the Bureau of Plant Industry, Department of Agriculture, for duty in the field. At present there is a vacancy in the associate grade at Bellingham, Wash., and there are vacancies in the assistant grade at Huntley, Mont., and Fort Collins, Colo.

Competitors will not be required to report for examination at any place, but will be rated on their education, training, and experience, and on a thesis or publications filed with the Commission.

Full information may be obtained from the United States Civil-Service Commission Washington, D. C., or the Secretary of the United States Civil-Service Board of Examiners at the post office or customhouse in any city.

A DELICATE PROCEDURE FOR QUALITATIVE DETECTION OF TIN

WILFRED W. SCOTT AND CHARLES L. KOELSCHE, UNIVERSITY OF SOUTHERN CALIFORNIA, LOS ANGELES, CALIFORNIA

This procedure for analysis of tin was formulated after a thorough study and laboratory experimentation of several of the up-to-date methods used by prominent authors in their texts on qualitative chemical analysis.

The reason for this research is that nearly all students studying qualitative analysis have difficulty in securing good and reliable tests for tin, and especially in the presence of arsenic and antimony. The objective of this work was to formulate a procedure which would eliminate the difficulties to a minimum, thereby enabling first-year students to secure more reliable results.

A comparative study was made using the procedures generally followed in several of the standard methods. The solutions used generally contained 50 mg. of arsenic and 50 mg. of antimony, but the content of tin was varied. Results were noted and carefully recorded. If results were in doubt the specific experiment was repeated. On the whole, tests were obtained when 25 mg. of tin were used in the presence of 50 mg. of arsenic and 50 mg. of antimony, but when 5 mg. of tin were used, it took very careful execution of steps to secure tests. With only one procedure was a test obtained for tin when 1 mg. was present with 50 mg. of arsenic and 50 mg. of antimony.

In the procedure that we have developed, positive tests for 1 mg. of tin were obtained in the presence of 500 mg. of impurities. The impurities are equal amounts of arsenic and antimony. Positive tests for 2 mg. of tin were also obtained in the presence of 1000 mg. of impurities.

<table>
<tr><td colspan="3">Treat the ammonium polysulfide solution from Division A of Group II with dilute HCl (1:1) until solution is slightly acidic. Filter. Wash precipitate.</td></tr>
<tr><td>Filtrate:
Disregard</td><td colspan="2">Precipitate: arsenic sulfide, antimony sulfide, and tin sulfide. Transfer precipitate to beaker, and add 15 cc. concn. HCl. Heat to 90°C. Stir frequently, keeping the temperature constant for 5 minutes. Add 10 cc. H_2O, and filter.</td></tr>
<tr><td></td><td>Residue:
Arsenic</td><td>Filtrate: antimony chloride and tin chloride. Heat filtrate to boiling to expel all the H_2S. Remove flame, and add a piece of aluminum sheet metal $^1/_{16}'' \times ^1/_4'' \times 1''$. Stir constantly while the reducing reaction continues for two minutes. Black precipitate is metallic antimony. Solution contains tin. Filter directly into a test tube containing 5 cc. $^2/_{10}$ N $HgCl_2$ solution. A white or gray precipitate indicates tin.</td></tr>
</table>

Two of the main difficulties noted were that of reducing tin before making the final test, and controlling the acid concentration after extraction with concentrated HCl. Stannic tin is the only form of tin that can exist

after warming the sulfides of arsenic, antimony, and tin with concentrated HCl. Tin must be in the stannous form in order to give a test with mercuric chloride. Therefore, the matter of a suitable reducing agent is very important. The acid concentration is easily controlled by proper dilutions. These two difficulties have been overcome in our procedure given on page 367.

Notes—*Acid Concentration:* If the HCl extraction of the sulfides of arsenic, antimony, and tin is diluted too much, antimony sulfide will be precipitated. This in turn is apt to bring some tin sulfide with it. Therefore, the dilution must be made as specified. The heating of the HCl during digestion must be done with care, because if the temperature goes over 90°C. some of the arsenic sulfide may dissolve and cause difficulty in the detection of antimony and tin. If an unusually large precipitate results from treating the ammonium polysulfide solution from *Division A* with dilute HCl, extract the precipitate with 20 cc. of concentrated HCl instead of 15 cc. This in turn requires 12 or 13 cc. of H_2O for dilution instead of 10 cc.

Reducing Reaction: To make sure that the amount of aluminum sheet metal used was not too large, 2 mg. of stannic tin were used and reduced alone with the amount of aluminum specified. The reaction continued for approximately two minutes. This solution was filtered into 5 cc. of 0.2 *N* $HgCl_2$ reagent, and a perfect test for tin was obtained. With antimony present the reducing action is lessened on the tin. This amount of aluminum will reduce sufficient stannic tin in the presence of large quantities of antimony to give the mercury chloride test.

In the section where antimony is separated from tin by being reduced to metallic antimony, if large quantities of it are present, this amount of aluminum will not precipitate it all. The antimony in solution is $SbCl_3$ which is insoluble in HCl in lower concentration than 1:1. Therefore, if a large white precipitate is obtained when the solution from the reducing reaction is filtered into $HgCl_2$ reagent, add 10 cc. concentrated HCl. The acid will dissolve the precipitate if this is due to antimony, but will not dissolve HgCl resulting from reduction of $HgCl_2$ by tin.

Scrubbing Organic Gases with Active Charcoal. Active charcoal has appeared to advantage in comparison with paraffin oil as an agent for removing vapors of organic liquids from gas mixtures. The applicability of active charcoal to difficult recovery problems is such that it is being successfully used for separation of benzol from coal gas, gasoline from natural gas, ether, acetone, and alcohol from effluent gases from celluloid and film manufacture, and solvents from rubber-processing vapors. It is a peculiar property of active charcoal that many specimens are active catalysts of gas reactions. There is no apparent relation between adsorption efficiency and catalytic activity; some specimens are active in both respects, and some much more in one than the other.

These experimental results, described by W. Kärsten in *Teer und Bitumen* recently, show a clear superiority of adsorption over absorption as a means of solvent recovery, particularly in the low concentration ranges which are important commercially. Adsorption has the further advantage that the solvent or liquid is recovered in a purer state than by absorption, and that reactivation of active charcoal is cheaper than the purification of spent paraffin or scrubbing oil. Large-scale applications are cited where active charcoal is used in the recovery of gasoline from natural gas, and of benzol from coal gas. The principles to be followed hold equally for recovery of volatile solvent vapors in the process industries.—*Chem. and Met. Eng.*

THE ATLANTA MEETING OF THE AMERICAN CHEMICAL SOCIETY

April 7–11, 1930

According to the preliminary announcement which appears in the January 20th *News Edition* of *Industrial and Engineering Chemistry*, a most attractive program of papers is assured for the spring meeting of the A. C. S. In addition, those who have experienced southern hospitality know what a social treat is in store.

Program

Monday, April 7th, will be devoted to registration, council meeting, etc. **Tuesday, Wednesday,** and **Thursday** will be given over largely to program meetings of the numerous Divisions of the Society, while special trips are arranged for the latter part of the week.

The program of the Division of Chemical Education will include a Symposium on the Relation of Cotton to Chemical Industry and papers on miscellaneous subjects. DR. CHAS. H. HERTY will preside at the Symposium.

Senate of Chemical Education

The Senate will meet Wednesday morning, April 9th, at 8 o'clock. The standing committees will report at this time.

High-School Teachers

The Division is anxious to establish contacts with every teacher of chemistry in the Atlanta area. On Wednesday, April 9th, the Division and Senate will be hosts to all the high-school chemistry teachers, through the courtesy of Mr. Wm. W. Buffum. These teachers will also be invited to attend the morning and afternoon sessions of the Division.

Exhibits

Manufacturers of chemical apparatus and products, high-school and college laboratories, and other agencies which are interested in chemical education are invited to send exhibits for the Atlanta meeting. Free exhibition space will be reserved upon request to the *Local Secretary*, but each exhibitor must assume all costs of transportation and packing, as well as responsibility for breakage and loss.

A prize of $10.00 is offered by the Division for the best exhibit prepared by a high-school chemistry class. Exceedingly instructive and attractive exhibits were shown at the Columbus meeting in the spring of 1929. A description of them appeared in THIS JOURNAL, **6**, 1153–5 (June, 1929).

Papers for the Program

By vote of the Council of the A. C. S., papers by American chemists not members of the A. C. S. shall not appear on the program unless they be

joint papers with Society members, and no papers may be presented at a meeting unless the title has been printed on the final program.

Titles for papers designed to be read before the Division of Chemical Education should be sent to the *Secretary* (R. A. BAKER, Syracuse University, Syracuse, New York) of the Division as soon as possible. Be sure to state whether or not a lantern will be required.

The completed paper, accompanied by an abstract (in duplicate) of about 100 words must reach the *Secretary* not later than February 25th. Papers received after this date will be held over, with the consent of the authors, for the September meeting.

Papers read before the Division become the property of the Division, and, if acceptable for publication, will appear later in THIS JOURNAL.

Since the time available for the reading of papers will be strictly limited, each author is requested to condense his material, leaving time for adequate critical discussion which is the chief function of our program meetings. In general only 15 minutes, including discussion, may be allotted to each paper.

Special Student Rates

Regularly matriculated students majoring in chemistry in any college or university will be registered for the entire meeting for $3.00 which is the differential fee charged regular members of the Society. Sleeping accommodations will also be provided for them in the headquarters hotel at $1.00 per night. To insure this concession, arrangements must be made *in advance* of April first through the *Local Secretary* of the Division, MR. M. A. GAERTNER, 39 East Drive, Atlanta, Georgia.

R. A. BAKER, *Secretary*,
Syracuse University,
Syracuse, New York

Vacuum Tube Produces Artificial Radium Rays. Artificial radium rays, produced by 1,600,000 volts of electricity in special vacuum tubes, have now been achieved by physicists at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. At the Institution's recent annual exhibit of its research activities, the tubes for producing these rays are being shown.

The tubes are really X-ray tubes, and by applying voltages of from one-half to several million, rays similar to the gamma rays of radium are emitted. The other kinds of radium rays, known as alpha and beta rays, can be produced by suitably modifying such a tube. With the aid of these rays, the Carnegie physicists are studying the structure of the heart of the atom.

The tube is composed of many separate X-ray tubes, with the rays feeding from one into the next. The entire battery of tubes is immersed in oil, while each one is individually shielded from the others. This makes possible smaller tubes, and higher voltages, than Dr. W. D. Coolidge, of the General Electric Co., used in a somewhat similar experiment.—*Science Service*

TRENDS AND TENDENCIES IN THE TEACHING OF CHEMISTRY IN NORMAL SCHOOLS AND TEACHERS' COLLEGES*

ALICE M. VANDEVOORT, UNIVERSITY OF DELAWARE, NEWARK, DELAWARE

The purpose of this report is to present, in part, the results of an investigation carried on by the author to determine some of the significant trends and tendencies in the professional training of the teacher of science in normal schools and teachers' colleges.

Space cannot be given in this article to a detailed description of such items as the source of data or the method of investigation. Such detailed discussion will be found in the published report of the investigation,[1] which includes a study of the teaching of chemistry, physics, biology, general science, and nature study. The present report is but a part of the larger study and deals with trends and tendencies in the teaching of chemistry.

Period—1832–80

The study of chemistry has been required of students by state normal schools since the establishment of these institutions in the second quarter of the nineteenth century. It appears, therefore, that during this period, which covers almost one hundred years, many changes have taken place. The original courses of study in each of the early state normal schools began with a review of the studies pursued in the common schools—reading, writing, orthography, English grammar, mental and written arithmetic, geography, and physiography. The attention of the pupils was directed, first, to a thorough review of elementary studies, and second, to those branches of knowledge which might be considered an expansion of the above-named elementary studies, as collateral to them and to the "art of teaching and its modes." Among the branches considered as an expansion of the elementary branches was included that portion of chemistry which is related to the atmosphere, the water, and the growth of plants and animals.[2]

The Massachusetts law requiring the establishment of high schools, created a demand for a type of teachers which the existing institutions did not furnish[3] and in order to supply better-trained secondary teachers, the normal schools of the state, in 1850, offered instruction to those students who wished to prepare themselves to teach science in high schools. These normal schools were equipped with "sufficient and well-assorted

* *See* "Chemical Education in Sixty-Nine State Teachers' Colleges and Normal Schools" by E. F. Walker, THIS JOURNAL, **6**, 1328–30 (July-Aug., 1929).

[1] ALICE M. VANDEVOORT, "The Teaching of Science in Normal Schools and Teachers' Colleges," Teachers' College, Columbia University, Contributions to Education, No. **287** (1928).

[2] General catalog of the State Normal Schools, West Newton, Mass., **1850**, pp. 26–27. *Barnard's Am. J. Educ.*, **16**, 102–5 (1866).

[3] *Barnard's Journal*, **1**, 74 (1851).

apparatus" for illustrating the principles of natural philosophy and chemistry. As far as practicable, the instructors used, in their classes, apparatus that could easily be made by the teachers themselves or procured at low prices, and be made useful in the instruction of district schools.[4]

The trend in the preparation of science teachers for the secondary schools was further indicated in the course of study offered in 1865.[5] The regular course included natural philosophy, chemistry, and botany—subjects which were prescribed by law for the high schools of Massachusetts. *The Annual Report* of the Executive Committee of the State Normal School of Albany, New York, made to the legislature in 1846, contained a course of study similar to that prescribed for the normal schools of Massachusetts. Chemistry with "experimental lectures" was required of "male students." Apparatus was provided for illustrating "all of the important principles" in natural philosophy, chemistry, and human physiology; and "several valuable standard works" upon the natural sciences were purchased for the library. Silliman's Chemistry[6] was the textbook used. An account of the expenditures for that year included "cash" paid for apparatus and chemicals.[7] Previous to 1863, the course of study offered in the State Normal School of Ypsilanti, Michigan, embraced the ordinary branches taught in the other normal schools. In 1863,[8] however, the board of education made certain modifications in the several sciences: "object lessons in common things," botany, zoölogy, and "properties of teaching with lectures" were given in the primary; and natural philosophy, botany, and chemistry in the higher normal course. The "model school" offered courses in the above-mentioned subjects.

During the "seventies" the courses in science offered by the State Normal School of Ypsilanti, Michigan, included botany, zoölogy, natural philosophy, chemistry, geology, and astronomy. In 1879, Professor Lewis McLouth, in an address before the National Education Association, gave in detail the method employed in "Observation and Participation"[9] for the preparation of the chemistry teacher. Professor McLouth stated that, as far as possible, the instruction was made "objective and experimental." The work was done by "pupil-teaching." The "pupil-teachers" met the teacher "in charge" at least once a week for examination and assignment of the work, clearing up obscure points, determining the "order and manner" of the topics, and the extent of the daily lesson. The pupil-

[4] *Barnard's Journal*, **17**, 710–1 (1867).

[5] Catalog and Circular of the State Normal School at Bridgewater, Mass., **1865**.

[6] Quinquennial Register and Circular of the State Normal School at Albany for the First Five Years, **1849**, p. 33.

[7] Report of the Executive Committee of New York State Normal Schools, 1849, p. 17.

[8] *Barnard's Journal*, **17**, 723–4 (1867).

[9] MCLOUTH, LEWIS, in *Proc. Nat. Educ. Assoc.*, **1879**, p. 132.

teachers prepared the apparatus and performed all of the experiments that were to be made. Then one of the number was assigned the work of teaching the class for a week, another to assist at experiments, and the rest to act as "observers and critics." At the end of the week a "critical review" of the work was given by the teacher in charge, suggestions and criticisms were offered by the observers, and another portion of work was planned.

The teaching of chemistry to secondary students began in the academics prior to 1820.[10] It was at this time that an organized attempt was made to promote instruction in secondary school science. During the period from 1832 to 1880, varied discussions occurred in addresses and educational publications as to the purpose and content of science courses for public schools, the methods of presenting the subject to the pupils, and the peculiar training that the teachers should receive.

In 1834, Dr. Jackson[11] delivered a lecture on the history and uses of chemistry, wherein he emphasized its usefulness to every man, whatever his calling. He showed the application of chemistry to the arts; to the medical practitioner; to the lawyer, in order that he might be able to understand the testimony of medical witnesses and to "discern between truth and error" in chemical evidence; to the agriculturist; to the preacher of the gospel, in order that he might be able to "devise" illustrations of the benevolence of the Deity from meditation on the laws that regulate the combinations of matter. Dr. Jackson considered the educational value of chemistry so great that he advocated the enforced study in both high school and college. Reverend Thomas Hill,[12] in 1857, gave an interesting outline of "The True Order of Studies" wherein he states that the subject of chemistry should be studied at the age of nine or ten because at that time of the child's life the simplest phenomenon of change "begins to excite" his curiosity.

"Methods" of teaching the sciences in both common schools and teacher-training institutions emphasized the advantage of various types of illustrations. An article entitled "The Utility of Visual Illustrations"[13] contained a statement to the effect that the truth of many sciences would never reach the minds of the majority of mankind except by their connection "with visible illustration." Dr. J. W. Dawson,[14] in 1857, expressed

[10] POWERS, S. R., "The Teaching of Chemistry in the Early American Schools," *Sch. & Soc.*, **24** (Oct. 23, 1926).

[11] JACKSON, DR. C. T., "The History and Uses of Chemistry," *Am. Inst. of Instruction*, **1834**, pp. 209–24.

[12] HILL, REV. THOMAS, "The True Order of Studies," *Barnard's Journal*, **7** (1859).

[13] JOHNSON, WALTER, "The Utility of Visual Illustrations," *Am. Inst. of Instruction*, 1832, p. 98.

[14] DAWSON, J. W., "Natural History in Its Educational Aspects," *Barnard's Journal*, **3**, 431 (1853).

the opinion that much of the teaching of natural history by object lessons and popular textbooks was too inaccurate and superficial, and too deficient in "enlargement of view" to be really useful. He stated that in colleges and scientific institutions "nature" should be illustrated by the best possible collection of typical forms, explained and examined under the guidance of the best scientific skill, and that similar "influence" should be used in the training of the teacher.

Period—1880–1910

The school year of 1880–1881, marked the beginning of individual laboratory work in the Massachusetts' Normal Schools.[15] The "distribution and range of studies" for the two-year course embraced chemistry, including chemical physics and inorganic chemistry, with laboratory practice by each pupil. The four-year course included the subjects of the two-year course with the addition of qualitative analysis and organic chemistry. Practice teaching in the sciences was not definitely mentioned, yet the "design" of the normal school as stated by the board of education would seem to justify the inference that it was employed:

> The design of the normal school is strictly professional..... To this end there must be the thorough knowledge, first, of the branches of learning to be taught in the schools; second, of the best methods of teaching those branches; and third, of the right mental training.

By 1885, however, practice teaching in the sciences was required;[16] each student prepared the apparatus, performed the experiments in the laboratory, observed, recorded his observations and inferences, made application and taught. The four-year course included qualitative analysis in which the student in addition to preparing chemicals and apparatus and doing practice teaching throughout the course was given instruction in "chemical philosophy." By 1895 courses in "Methods of Teaching"[17] the respective sciences had a place in the curriculum.

During the "nineties" the New York State Normal School[18] was chartered as a college and empowered to confer degrees in pedagogy; no opportunities, however, were offered for the pursuit of courses of study similar to those pursued in ordinary liberal arts colleges. The subjects of the usual liberal arts courses were not taught, but only methods of teaching those subjects. This teachers' college now boasted the "unique equipment" of every form of school, kindergarten, primary, grammar, and high

[15] Catalog and Circular of the State Normal School at Bridgewater, Mass., **1880–1881,** pp. 14, 15, 21, 22.

[16] *Ibid.*, **1885–1886,** pp. 22–3.

[17] *Ibid.*, **1895–1896,** pp. 20–1.

[18] Circular and announcement of courses of the State Normal School at Albany, N. Y., **1895–1896,** pp. 7, 16, 33.

school. Teaching in the model school was done briefly by the students under the guidance of a teacher who, from time to time, taught model lessons. The curriculum included a course in methods of teaching chemistry and preparing apparatus.

An analysis of the catalogs of the normal school at Ypsilanti[19] showed that the preparation of science teachers held a prominent place in the work of the institution. By 1885[20] teachers of botany and zoölogy, for both elementary and secondary schools, and of chemistry received special training. All courses in science were planned to meet the needs of pupils "considered as students and as prospective teachers." Among the results to be secured from this work were the acquisition of both "academic and professional" knowledge, a clear conception of the function of science in the public school curriculum, the ability to carry on independent investigation, and a love of scientific truth. During the session of 1900 and 1901[21] some of the students did their practice teaching in the laboratories of the college, although practice teaching in the sciences was also carried on in the training school.

A survey of certain educational publications for the period from 1800 to 1910 indicated that there was great diversity of opinion in reference to what should be included in the normal school curriculum; whether methods should be given in connection with new subject matter; the purpose of academic knowledge; the difference between academic knowledge and teaching knowledge; the meaning of the "educational" or professional study of academic subjects; the general qualifications of the teacher; what should be included in the science courses of the public schools; and the best methods of teaching science.

Period 1910–20

By 1914[22] all work in physics and chemistry offered by the Massachusetts normal schools was embraced in "Practical Science," and by 1920[23] all science courses, except biology, were included under "General Science." The first course in general science dealt with the subject of chemistry, and its principal aim was to form the basis for the later courses in industrial chemistry; the second dealt with physics; the aim of the third, "economic chemistry," was to prepare for those projects in general science in the junior high school that involved a general knowledge of chemistry. The students preparing to teach in the junior high schools

[19] Calendar of Michigan State Normal School, **1881–1882,** pp. 17–9; **1890–1891,** pp. 51–4.

[20] *Ibid.*, **1885–1886,** pp. 22–4.

[21] *Ibid.*, **1900–1901,** pp. 79, 90.

[22] Catalog and circular of the State Normal School at Bridgewater, Mass., **1914–1915,** pp. 23, 31, 32.

[23] *Ibid.*, **1919–1920,** pp. 31, 32.

were expected to elect certain major groups in which to prepare for departmental work.

At the school in Albany[24] the "broader training" phase was reflected in the change from a purely method curriculum to one of content and method. Under chemistry were included a general course, advanced inorganic, qualitative analysis, organic, and methods of teaching. By 1920[25] the courses in chemistry were increased by the addition of chemistry of nutrition; chemistry of foods; organic chemistry and food analysis; chemical physics; electro-chemistry; metallurgical chemistry; industrial and applied chemistry; "service" chemistry; history of chemistry; and the "development of chemical theory." The courses in the "theory and practice" of teaching chemistry were followed by practice teaching. "Model lessons" given by the supervisor preceded practice teaching by the student.

The emphasis placed upon science at Ypsilanti[26] was indicated by an account of additions made to the various departments, the well-equipped laboratories, and extensive collections of books on the subject. A rich course was offered in chemistry including general chemistry; qualitative analysis; quantitative analysis; organic chemistry; methods of teaching and laboratory supervision; chemistry of nutrition and of foods; chemistry of foods; chemistry of textiles; industrial and applied chemistry; and history of chemistry.

An examination of certain educational periodicals during the period from 1910 to 1920 revealed that leaders in the field of education were struggling with many and varied problems, among which may be mentioned those relating to the general qualifications of the teacher; the province of academic training; the development of subject matter together with methods versus separate development; the advantages of differentiated curricula; the differentiating or "professionalizing" of content courses; the training necessary for the successful teacher of science; broad training versus high specialization; the training necessary for the teacher of general science, of biology, of physics, of chemistry; principles from the re-organization of the high-school science curriculum and for the selection and organization of subject matter; the meaning and aims of science teaching; the relation between science and literature; the function of a study of the history of science; the aims and methods of science in the high school; methods of relating the subject to the life of the student; the value of the project and the project method in teaching science; the place of the

[24] Circular and announcement of the courses of the New York State Normal College, N. Y., **1909–1910,** pp. 55, 56, 57, 58.

[25] *Ibid.*, **1920–1921,** p. 13.

[26] The Year Book of the State Normal College at Ypsilanti, Mich., **1910–1911,** p. 28.

laboratory in instruction; and the best means of testing the efficiency of science teaching.

Present-Day Period

A study of the catalogs of ninety normal schools and teachers' colleges for the years 1923–1924 and 1924–1925, distributed among thirty-five states, showed a remarkable variety of science courses.[27] Chemistry had a showing of 612 courses included under 66 titles. Though the titles reflect limitation of a field, emphasis of content or method of treatment, applied subject matter, professional implications, etc., it is found that when the title is read in connection with the course description, it is not always a safe indication of the subject matter included in the course nor of its function in the curricula offerings.

The titles and descriptions, though not occurring together, indicate that the courses comprise professional content and take note of the various "elements" essential to the professionalization of courses for teachers. There are still many titles and descriptions that represent a general survey of subject matter with no consideration of anything but mastery of subject matter; as, for example, 300 courses in general organic and inorganic chemistry. An idea of the nature of courses comprised under "general" may be obtained from the following quotation:

> **General Chemistry.**—*A first-year college course.* The fundamental laws and theories of the science of chemistry are developed. Chemical symbols, formulas, and equations are made clear and workable. The problems of stoichiometry are mastered. Chemical manipulations and skill with apparatus are acquired by the preparation and isolation of some of the simple elements and the material of the course is so organized as to give a definite conception of the structure of matter. This is a course of broadening information essential to every educated person.—KENT, OHIO.

Of the 612 courses in chemistry offered by the 90 colleges, 23 have titles: "Teachers' Course," "Teaching of," "Methods of," and "Practice Teaching;" "History of Chemistry," "Laboratory Technic and Manipulation," and "Supervision" in chemistry also receive mention. Many of the courses are described as basis or foundation courses. A large number of introductory statements concerning the science departments maintain that the subject matter as a whole is of a professional character.

Some of the many interpretations placed on the phases, "Teaching of," "Methods of," "Teachers' Course" and "History of," are illustrated by the following quotations:

> **The Teaching of High-School Chemistry.**—This course is intended to present to teachers of chemistry in the secondary schools the application of the principles of psychological methods to the subject matter of chemistry. It deals also with such problems as the selection, purchase and placing of chemical equipment, the purchase of chemicals,

[27] VANDEVOORT, ALICE M., *loc. cit.*, pp. 34–42.

the arrangement of reagents in the laboratory and storerooms, and the orderly management of laboratory sections. In short, an effort is made to anticipate, and effectively to solve those problems of method, subject matter and management which arise in the teaching of chemistry in the high school.—DENTON, TEXAS.

Methods of Chemistry.—Theory of chemistry as the basis for correct method of presentation in the laboratory and classroom. Principles of induction as applied to chemistry. Logical order of presentation, topics to be included, relation of laboratory and classroom. Planning and presentation of lesson.—ALBANY, NEW YORK.

The History of Chemistry.—This course is intended primarily for students who are majoring in chemistry and who are hence preparing to teach the subject, but it is open to others who are prepared to take it. Chemistry among the early peoples, the opinions and theories which led to the chemistry of today, and the present status and trend in the science. Library reading and reports are required of the students.—DENTON, TEXAS.

Certain topics which may be considered "elements" of professional subject matter[28] in general, together with others which seem to belong peculiarly to the subject matter of chemistry, occurred in the catalog description of courses in the 90 normal schools and colleges in the following order: method of teaching and presentation, 29 times; aims, objectives, and values, 27; laboratory technic and demonstration, setting up apparatus, making and repairing apparatus, 15; planning and equipping laboratory, 12; selection and organization of subject matter, 10; history of chemistry, 7; observation and practice teaching, 6; psychology of the subject and psychological arrangement, 4; reviews and evaluation of textbooks 3; project work, motivation, red letter days, 2; making lesson plans, 2; measurements of results and study of tests, 2; collecting and preserving materials, 1; field trips, 1; reviews of the subject, 1; literature of the subject, 1.

Although the title "Practice Teaching" occurs only six times, it would be a mistake to conclude that to be the extent of the work. A survey of the courses offered in the departments of education showed that observation and practice teaching are required in most of the institutions. The agencies provided for this phase of the professional training of the teacher are: (1) some type of training school maintained by the college; (2) the public schools; (3) a combination of (1) and (2).

Data obtained from forty-five teachers' colleges and normal colleges in 1923–1924, by means of questionnaires and letters of inquiry showed interesting trends and tendencies in the teaching of chemistry. Twenty-three of the forty-five institutions offered "training courses" in chemistry. The types of chemistry courses given were grouped by officers of the respective colleges as follows: courses in which the treatment of subject matter is not differentiated from the academic, 88; advanced academic

[28] RANDOLPH, E. D., "The Professional Treatment of Subject Matter," **1927**, pp. 104, 105.

courses, 77; courses to form a basis or foundation for other subjects, 67; courses in which the subject matter is differentiated from the academic, 61; courses in observation and participation, 19; courses in practice teaching, 19; and review courses, 13.

The above-mentioned reports from the normal schools and teachers' colleges indicate that in these institutions practice teaching in chemistry is done under the direction of from one to three officers as follows: director of training school, critic teacher, teacher of science in the normal school.

Current educational literature indicates that the principal points at issue, apparently, are: the scholarship requisite as a basis for teaching; the adequacy of the training of science teachers for the subjects that they teach; causes for the lack of efficiency of the science teachers; the training in subject matter and in professional subjects necessary to qualify the teacher for this work; basic principles for the reorganization of the public school curriculum in science; evidences of principles of organization in current high-school textbooks; methods and principles for evaluating textbooks; factors influencing the teaching of science: the uses of the laboratory, the project method, the motion picture, and the new types of tests for measuring the results of teaching.

Bagley and Keith in "An Introduction to Teaching"[29] reflect the general theory with regard to the scholarship requisite as a basis for teaching by the statement that the present tendency is to lay a "heavier emphasis on mastery of subject matter," but this subject matter approached from the point of view of the specific needs of the teacher.

The adequacy of the training of science teachers for the subjects that they teach can be determined to some degree by an examination of their prospective field of work with special reference to the demand for teachers of the respective sciences, of the subject combinations that they are required to undertake, and of the content of the courses.

The demand for teachers of secondary science may be understood by a consideration of certain studies relative to the per cent of students registered in the respective science courses in the public schools, and of the science courses offered.

The report[30] of the Bureau of Education for 1924 showed that out of the total number of students enrolled in high schools, 8.93 per cent registered in physics; 7.40 per cent in chemistry; 5.08 per cent in physiology; 3.82 per cent in botany; 1.53 per cent in zoölogy; 8.78 per cent in biology; 18.27 per cent in general science.

[29] BAGLEY AND KEITH, "An Introduction to Teaching," Macmillan, New York, 1924, p. 15.

[30] U. S. Bureau of Education, *Bull. No.* **7**, 1924 (Statistics of High Schools, 1921–1922).

Holmquist[31] made a study of 109 of the 240 high schools of Minnesota, ranging in size from a school of 48 pupils to one of 3078 pupils. He reported that 70 per cent gave courses in general science; 30 in general biology; 23 in zoölogy; 28 in botany; and 23 in physiology.

A study of the science courses given in twenty-seven high schools of Delaware[32] showed that general science is required of all ninth-grade students, and is therefore taught in twenty-seven schools; biology is offered annually in twenty-six schools, and alternate years in the remaining school; chemistry is taught annually in seven and during alternate years in nine schools; physics is offered annually in nine and during alternate years in eight schools.

Studies indicate that there is a sequence in the teaching of science. Hunter's[33] report showed that of the schools reporting in 1923 general science courses comprise the greatest number of all science courses offered in the ninth grade; biology, botany, and zoölogy the greatest number in the tenth grade; and physics and chemistry, respectively, the greater number in the eleventh and twelfth grades. The report of the schools in Delaware showed that in 1927, general science was offered in the ninth grade, biology in the tenth, and physics and chemistry, respectively, in the two higher grades. Finley[34] surveyed and summarized several studies of the types referred to in the statements given above and reached the conclusion that there is a "fairly well-recognized science sequence" in our high schools.

The subject combinations required play such an important rôle that no thorough conception regarding the adequacy of the preparation of the teacher of chemistry can be gained without considering them.

The Montana Educational Directory for 1923–1924 gave nineteen county high schools; five high schools, first-class districts; fifty-one high schools, second-class districts; forty-seven four-year high schools, third-class districts; fourteen three-year high schools, third-class districts; and twenty-six two-year high schools, third-class districts.

The teachers were classified according to the subjects that they taught in the county high schools and in the first- and second-class districts. Teachers of the third-class districts, however, were not classified.

In the table below are given science combinations with other courses. Of the teachers giving the courses presented in this table, seventeen also had charge of athletics and four had charge of gymnasium, very few of

[31] HOLMQUIST, A. M., "The Biological Sciences in Minnesota High Schools," *Sch. Sci. & Math.*, **22,** 166–74 (1922).

[32] VANDEVOORT, ALICE M., *loc. cit.*, p. 61.

[33] HUNTER, G. W., "Is There a Sequence in Secondary School Science?" *Sch. & Soc.*, **20,** 762–6 (1924).

[34] FINLEY, C. W., "Biology in Secondary Schools and the Training of Teachers," **1926,** pp. 32–64. Bureau of Publications, Teachers' College, Columbia University.

them were listed to teach the separate sciences: one taught biology only; one, biology and music; one, chemistry only; and one, chemistry and physics.

TABLE I

Science Combinations with Other Courses in Seventy-Five Secondary Schools of Montana 1923–1924

Subjects	Number
Science and Manual Training	1
Science and Public Speaking	1
Science, Agriculture, Manual Training, and Mechanical Drawing	1
Science and Mechanical Drawing	1
Science, Economics, and Sociology	1
Science and Sociology	1
Science, Mathematics, and Mechanical Drawing	1
Science, Mathematics, Manual Training, and Mechanical Drawing	1
Science, History, and English	1
Science and Commercial Geography	1
Science, Manual Training, and Mechanical Drawing	2
Science and French	2
Science and Economics	2
Science, Mathematics, and History	2
Science, Mathematics, and Economics	2
Science and History	3
Science and English	3
Science and Agriculture	3
Science and Home Economics	4
Science and Mathematics	26
Science	44

The data given in Table II represent a report of a study of the science subject combinations in twenty-six of the high schools of Delaware.[35] The special district of Wilmington which is not included in this report employs fourteen teachers of science. Of this number one teaches chemistry only; two, physics only; three, biology only; and four, general science only; two, biology and general science; one, physics and general science; and one, civics and general science.

In 1923 Hutson[36] made a study of the high-school science teachers of Minnesota in relation to the subjects they were teaching and reached the conclusions that science teachers were teaching more subjects than they could be adequately prepared for; that for schools with faculties of less than ten the science teacher should be prepared to teach at least four subjects and that the lack of standardization in the small high school made difficult the adequate preparation of the teachers.

[35] VANDEVOORT, ALICE M., *loc. cit.*, p. 64.

[36] HUTSON, P. W., "High-School Science Teachers. A Study of Their Training in Relation to the Subjects They Are Teaching," *Educ. Admin. & Superv.*, **9**, 423–38 (1923).

TABLE II

Science Subject Combination with Separate Sciences and with Other Subjects in Twenty-Six Secondary Schools of Delaware 1926–1927

Subject combinations	Number
Biology, Chemistry, and Agriculture	1
Biology, Physics, and Agriculture	1
Biology, Latin, and Mathematics	1
Biology, Latin, French, and English	1
Biology and Mathematics	1
Chemistry and Agriculture	1
Chemistry, Physics, and Mathematics	1
Chemistry and Mathematics	1
Chemistry and Home Economics	1
Chemistry, Mathematics, and Home Economics	1
General Science, Biology, and Chemistry	1
General Science, Biology, and Home Economics	1
General Science, Biology, and French	1
General Science, Biology, and Physics	1
General Science and Agriculture	1
General Science, Agriculture, and Physics	1
General Science, Chemistry, and Physics	1
General Science, Chemistry, Physics, and French	1
General Science and History	1
General Science and English	1
General Science, Home Economics, and Mathematics	1
General Science and Latin	1
General Science, Latin, Physics, and Mathematics	1
General Science and Physical Education	1
Physics and Agriculture	1
Biology, Chemistry, and Mathematics	2
Biology, Physics, and Chemistry	2
Biology and Home Economics	2
Biology, Physics, and Mathematics	2
General Science, Biology, and Mathematics	2
General Science and Social Studies	2
Biology and Social Studies	3
Biology and Agriculture	3
General Science and Biology	3
General Science and Home Economics	7

Hutson's study gave some idea of the specific preparation of science teachers for their work. For instance, it showed that 51 per cent had received special preparation for teaching chemistry; 16 per cent for physics; 13 per cent for botany; 16 per cent for zoölogy; 3 per cent for physiology; and 1 per cent for physiography. This led him to the conclusion that few science teachers are fitted to teach the combinations of subjects required.

The inefficiency of the teacher of secondary science may be due to a variety of causes. Only two, however, will be mentioned at this time:

the subject matter combinations referred to in the foregoing statements, and the tendency on the part of the prospective teacher to specialize. That narrow specialization will not meet the needs of the teacher of secondary science is evident when the subject matter offered in general science (the most widely taught of all the sciences) is considered.

The table below, taken from a study by Webb,[37] shows the number of pages in eighteen general science textbooks devoted to the subject matter of the respective special sciences.

TABLE III

Subject Matter of Eighteen General Science Textbooks

Special science	Number of pages
Physics	2212.5
Physiography	1264.5
Biology	908.0
Physiology	885.5
Chemistry	632.0
Household Arts	343.5
Astronomy	271.5
Miscellaneous	120.5

The consensus of opinion in reference to the training in subject matter necessary to qualify the chemistry teacher for his work seems to signify a broad knowledge in preference to high specialization—extensive rather than intensive. Eikenberry[38] holds the opinion that the training of science teachers should be broad enough to include "earth sciences," botany, zoölogy, physics, chemistry, human physiology, hygiene, and some knowledge of the industries that rest upon science. Powers'[39] study led him to the conclusion that:

> The outstanding need is for a grouping of training subjects so that graduates will be prepared for the subject combinations for which teachers are demanded.

Brownell[40] holds that the methods of teaching science may be studied to better advantage in connection with the mastery of difficult portions of the subject matter. The Committee on Reorganization of Science recommends that every science teacher have at least a general course in psychology and the North Central Association recommends certain types of courses including educational psychology and observation and practice teaching.

[37] WEBB, H. A., "General Science Instruction in the Grades," p. 9.

[38] EIKENBERRY, W. L., "The Teaching of General Science," **1922,** 135–7.

[39] POWERS, S. R., "The Training of Science Teachers in Subject Matter," *Gen. Sci. Quart.*, **8,** 485–6 (1924).

[40] BROWNELL AND WADE, "The Teaching of Science and the Science Teacher," 1926, pp. 138–41.

An application of basic principles as stated in "Cardinal Principles of Secondary Education" has been made in a reorganization of high-school science. The "Committee on Reorganization" suggested the manner in which the study of science may contribute to the realization of these objectives; it outlined objectives for each of the separate high-school sciences; it recommended sequences in the junior-senior high school, the large comprehensive four-year high school of medium size, and the small high school.[41]

That authors of textbooks are alert to certain principles of organization of subject matter is indicated by the "forewords" in some of their books. Smith and Jewett, for instance, in "Introduction to the Study of Science" claim to place emphasis upon the "psychological arrangement" rather than the traditional.

Several efforts have been made to determine the best methods and principles for evaluating science textbooks, notably in the field of general science. Bakke,[42] in 1921, worked out a score card for general science texts; Petersen[43] presented another, longer and more detailed; and Stack[44] offered a third. He evaluated the text in terms of its worth as a help in a realization of the objectives of education as set forth in "Cardinal Principles of Secondary Education."

A wider use of the laboratory, the motion picture, the project and the project method, and the new type of tests are factors that are having a far-reaching effect on the teaching of science.

One educator[45] has stated that the laboratory is the "one spot" in which the students' ability to initiate and to correlate are put to the test. The last-named factor—the standard test—affected the teaching of other subjects earlier than science on account of difficulties in constructing tests. These difficulties included lack of agreement as to content of courses; differences in aims on the part of the respective teachers; and lack of agreement in regard to the relative weights to be given to different parts of the tests. Several tests in general science, biology, physics, and chemistry have, however, appeared within recent years. Among those relating specifically to chemistry are: "Chemistry Tests" by H. L. Gerry;[46] "Chem-

[41] U. S. Bureau of Education, *Bull.* No. **26,** 1920.

[42] BAKKE, N. H., "Scoring General Science Text and Course," *Gen. Sci. Quart.*, **5,** 61–5 (1921).

[43] PETERSEN, A., "A Score Card for Judging the Value of General Science Textbooks," *Sch. Sci. & Math.*, **22,** 464–8 (1922).

[44] STACK, H. J., "Score Cards for General Science Textbooks," *Sch. Sci. & Math.*, **28,** 724–7 (1923).

[45] STONE, C. H., "The Teaching of High-School Chemistry," *Proc. Nat. Educ. Assoc.*, **1922,** pp. 1247–53.

[46] GERRY, H. L., "Chemistry Tests," Harvard University Press, **1926.**

istry Tests" by S. G. Rich;[47] and "Chemistry Tests" by S. R. Powers.[48]

Summary and Conclusions

During the early period, from about 1832 to 1880, chemistry of the informational type was taught by lecture with illustrative experiments. The mental training aspect of the subject was emphasized. Model schools were maintained. During this period, and the one immediately following, professional training placed emphasis on the making and repeating of outlines of logically arranged subject matter. Men of vision, however, conceived the idea that subject matter and methods could be integrated in courses that would meet the peculiar need of the teacher. The period that followed, 1880 to 1910, was characterized by an organization of subject matter according to the dictates of pure science. Provision was made for individual laboratory work. The use of the inductive method was emphasized. For a considerable part of this period, method courses entirely displaced subject-matter courses from the curricula of some of the normal schools. The more liberal training phase, however, gained advocates who fostered the conception that the most desirable training for the teacher could be accomplished by presenting material in a manner that would cause him to analyze his own learning process while acquiring a knowledge of the subject matter in question. The third period, 1910 to 1920, was characterized by an attempt to organize science for the public schools on the basis of certain fundamental principles. In normal schools and teachers' colleges, courses rich in subject-matter content now took the place of the pure methods courses. In addition to these subject-matter courses, psychology, principles and history of education, and observation and practice teaching were required. The idea that there was a need for a "unique" treatment of subject matter for all courses for teachers reached a state of fruition during the latter part of the period in the tendency to "differentiate" or "professionalize" content courses.

These tendencies, the shifting of emphasis, and some of the modifying influences are reflected in the amazing diversity of chemistry course titles—612 courses included under 66 titles. Although the titles and descriptions indicate that the courses comprise professional content there are still many titles and descriptions that represent a general survey of the subject with no consideration of anything but mastery of subject matter. One noticeable characteristic in attempts to adapt courses to the needs of teachers is to consider the courses as technical courses and describe them as "methods of" or "teaching of." Another manifestation of the recognition of the professional function is the appearance of typical ele-

[47] RICH, S. G., "Chemistry Tests," Public School Publishing Co., **1925.**

[48] POWERS, S. R., "Chemistry Tests," *School Science and Mathematics*, **21**, 366–77, (1921).

ments in course descriptions, as, "aims, objectives, and values," selection and organization of subject matter, project work, planning trips, equipping laboratories, setting up apparatus, etc. Additional evidence of the dual nature of the offerings is indicated in the classification of courses from questionnaires under: courses in which the treatment of subject matter is differentiated from the academic; courses in which the subject matter is not differentiated from the academic; academic courses; review courses; courses to form a basis or foundation for other courses; separate courses in methods; courses in observation and participation and courses in practice teaching. Of the 360 courses in chemistry represented in data from questionnaire, preparation for teaching is considered in 115 or 32 per cent of the offerings. The recognition of practice in the teaching of chemistry as essential in the preparation of teachers is evident from the fact that 42 per cent of the schools reporting offer practice teaching in chemistry.

The foregoing discussion relative to professional offerings, differentiation of courses, and provision for practice teaching, gives abundant evidence that those institutions which are teaching chemistry for the preparation of teachers are quite cognizant of their special problem.

An insight into the adequacy of the professional education of teachers of chemistry necessitates a study, first, of the demands upon the teacher of chemistry in the public schools in order that the teachers college offerings may be examined with these facts in view. Careful studies have been made which show these demands in a more or less detailed fashion. A survey of the secondary schools in Delaware showed a great demand for teachers of general science, as all schools in that state require the teaching of this subject in the ninth grade; biology is likewise offered as an elective in the tenth grade; physics and chemistry are offered for election in the eleventh and twelfth grades. Studies by Holmquist, Finley, Hutson, and Powers, which include other states in different geographical areas, show a similar sequence in high-school programs.

A study of science combinations does not show the same consistency as do the studies of sequence. Montana and Delaware present a wide variety in combinations. In Montana it is found that one instructor teaches biology only, and one chemistry only. In Delaware one teaches chemistry only, two physics only, three biology only, and four general science only. Studies by Hutson and Finley showed that very few instructors teach a single science.

A further study of the data referred to above shows a variety of combinations which cannot be justified on any rational basis pertaining to subject matter. The difficulties lie not alone in the combination of science materials, but also in the combination of science with other subjects; for example, science and French; science, mathematics, manual training, and mechanical drawing; science, history, and English; biology, Latin,

French, and English; general sciences and physical education. Another factor which further complicates adequate preparation of teachers of science is found in the materials to be included in the courses in general science.

Such dissimilarity as has been found in subject combinations, whether for administrative or other reasons, together with the extremely miscellaneous and scattered course materials, and the lack of principles generally agreed upon by curriculum specialists for the selection of curriculum materials in both secondary and professional schools, definitely point to the difficulty of giving a teacher adequate preparation for so undefined a task. However acute may be the awareness of the need for adapting materials to professional needs, accomplishment must necessarily wait upon the results of effort focused upon the specific problem of defining the work of the public school, which will direct the organization of the courses in professional schools.

A review of the writings of many outstanding thinkers bearing on topics in relation to the professional education of teachers in these phases of scientific education bears out by direct statement or implication, the foregoing conclusion as to the inadequacy of the preparation of teachers; the need for more definite professionalization of courses; provision for more specialized practice in teaching the subject matter of one's chosen field; the need of a degree of standardization of materials for specific administrative groups, the selection of which is based upon educational values and learning principles.

A study of the great mass of data assembled, analyzed, and interpreted seems to indicate that:

1. The general qualifications for the teacher of science should include the pursuit of courses of collegiate rank over a period sufficiently extensive to give a wealth of scientific knowledge organized and adapted for teaching purposes. This preparation should be supplemented by a thorough understanding of the principles essential for organizing and selecting educational materials and for adapting them to the individual needs of the learner at varying age levels. It is not intended to imply that either a narrow specialization or a rigid standardization is essential, but rather that a practical combination of subjects to be taught will determine the range of courses which a student can economically master in his pre-service education.

2. Courses for practice in the teaching of science should be organized and conducted for the purpose of making the student teacher familiar with the specific problems that arise in teaching science in the classroom at the administrative level upon which he will eventually serve. These practice activities should be closely correlated with the technical courses and the professional courses in subject matter for the purpose of integrating the materials of instruction and the principles of technical performance.

Though all teachers who contribute to any phase of the student teacher's professional preparation should be cognizant of the teaching problems in science, responsibility for the direction of practice in the laboratory school should be assigned to one person who is familiar with the technical principles involved in the teaching of science and with the materials in the branches which he will supervise.

3. The professional schools for teachers should assume serious responsibility for helping to define the educational values of science and should coöperate with the public school teachers of these subjects in selecting and organizing these materials for teaching purposes. This will serve to define more sharply the problems in their own institutions, and furnish suggestions for meeting their recognized obligations.

Acetonedicarboxylic Acid: It's a New Baking Powder. A baking powder which does not leave a residue in the finished bread or cake has just been worked out in the chemistry laboratories at the University of Wisconsin, by Edwin O. Wiig. This new leavening agent has as its active agent acetonedicarboxylic acid, which during the baking process disappears entirely as gases.

The formation of carbon dioxide, the gas which "raises" the cake, is only part of the story of baking powder. The other part concerns the product which remains in the cake as a residue. The various commercial baking powders on the market at present leave as residues saline cathartics, such as sodium tartrate, Rochelle salt, disodium phosphate, sodium sulfate, or aluminum hydroxide. There is still a question as to the possible ill effect of some of these materials upon health. Hence the advantage of a baking powder which leaves no residue whatsoever. Acetone is the only other substance formed besides carbon dioxide, and the acetone completely evaporates at baking temperatures.

The new powder depends for its action on combination with the water of the dough, just as do the present powders. Hence in order to protect it from atmospheric moisture it is mixed with starch. This cornstarch has a second function, more important than that just mentioned. Starch makes it possible for the chemist to standardize his product. All baking powders must have approximately the same "raising" strength to make possible the use of any recipe. The housewife-consumer will not consult the label of her tin of baking powder, and then compute whether the "two tsps. b.p." of her recipe should be doubled or halved. Starch takes care of any variation in the amount of carbon dioxide given off by active agents of differing compositions.

The keeping properties of acetonedicarboxylic acid baking powder are excellent, as Mr. Wiig has shown by various tests. It needs only to be kept in the customary moisture-proof tin. The keeping power of a product is of utmost importance to the manufacturer.

Further study of the suitability of acetonedicarboxylic acid as a leavening agent is being continued at the University of Wisconsin. The question of a cheaper source of raw material is still under investigation. At present citric acid is the raw material used in the making of acetonedicarboxylic acid. Cull lemons form the natural source of citric acid, and are the principal one in use. A shorter name for the substance would also be highly desirable, but that is a simple problem.—*Science Service*

POSITIONS OPEN IN VARIOUS COLLEGES AND UNIVERSITIES TO GRADUATE STUDENTS MAJORING IN CHEMISTRY

For several years THIS JOURNAL has published[1] a list, compiled by Wm. McPherson, of various Fellowships, Scholarships, and Part-Time Assistantships open for the ensuing academic year to graduate students majoring in chemistry in different colleges and universities. This present list, compiled in the editorial office of THIS JOURNAL, continues that custom. In addition to the institutions appearing in Dr. McPherson's most recent list,[2] an attempt has been made to include those on West and Hull's list.[3]

The Fellowships, Scholarships, and Assistantships listed below are for the academic year 1930–31. It is possible here to give only a very brief statement concerning these positions. Further details as well as application blanks may be obtained from the persons designated. In general it may be stated that candidates for these positions must file their applications not later than March 1, 1930. The colleges and universities are alphabetically arranged.

The editorial office would appreciate being advised of any errors or omissions in this present compilation.

Agricultural and Mechanical College of Texas, College Station, Tex.—6 Graduate Fellowships ($600 and exemption from tuition but not laboratory fees) in cotton-seed oil mill operations. Work leads to M.S. degree in Ch.E. Address inquiries to C. C. HEDGES.

Baylor University, Waco, Tex.—5 Part-Time Assistantships ($120 without remission of tuition of $180); eight hours' service required weekly in laboratory assisting and notebook grading. Address inquiries to W. T. GOOCH.

Boston College, Chestnut Hill, Mass.—4 Fellowships ($600 with exemption from tuition, laboratory, and breakage fees) restricted to candidates for M.S. degree. Nine hours' laboratory supervision required. Address inquiries to REV. JOSEPH L. SULLIVAN, S. J.

Brown University, Providence, R. I.—10 University Fellowships ($550–1000); 10 scholarships (stipend covering tuition). Holders of Fellowships, who report for duty on August 1st, are not required to pay tuition. Address inquiries to CHARLES A. KRAUS.

Bryn Mawr College, Bryn Mawr, Penna.—Helen Schaffer Huff Memorial Research Fellowship (physics or chemistry) ($1200); 1 Fellowship ($810); several Graduate Scholarships ($350). No exemption from tuition ($200). Occasional proctoring and library supervision required; Fellows not allowed to teach. Address inquiries to PRESIDENT MARION EDWARDS PARK or J. L. CRENSHAW.

California Institute of Technology, Pasadena, Calif.—4 Graduate Assistantships ($750); 6 Teaching Fellowships ($900); 1 du Pont Fellowship ($750). The tuition ($180) must be paid until the holder has been accepted as a candidate for the Ph.D. degree, then half tuition ($90) must be paid. Address inquiries to R. C. TOLMAN.

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[1] THIS JOURNAL, **4**, 96–8 (Jan., 1927); **5**, 338–42 (Mar., 1928); **6**, 109–14 (Jan., 1929).

[2] THIS JOURNAL, **6**, 109–14 (Jan., 1929).

[3] See Insert of "The Fifth Census of Graduate Research Students in Chemistry, 1928," C. J. West and C. Hull, THIS JOURNAL, **6**, 1338 (July-Aug., 1929).

Carnegie Institute of Technology, Pittsburgh, Penna.—Several Coöperative Fellowships with the Pittsburgh Station of the United States Bureau of Mines ($750). Address inquiries to JOHN D. BEATTY.

Case School of Applied Science, Cleveland, Ohio.—1 Grasselli Fellowship ($750); 1 Grasselli Scholarship ($500); 4 Drury Fellowships ($750); 3 Teaching Fellowships ($300 plus tuition and fees amounting to $350). Six hours per week of laboratory supervision required of teaching Fellows. Address inquiries to PRESIDENT W. E. WICKENDEN.

The Catholic University of America, Washington, D. C.—Several Knights of Columbus Scholarships (including board, lodging, and tuition). Open to Catholic laymen; awarded by competitive examination. Address inquiries to GENERAL SECRETARY.

Clark University, Worcester, Mass.—Several Scholarships for first-year graduate students ($200); 4 Part-Time Assistantships ($100–$150). No exemption from tuition ($200). Assistant may also hold Scholarship. Address inquiries to C. E. MELVILLE, *Registrar*.

Clemson Agricultural College, Clemson College, S. C.—1 Fellowship ($500). This is a part-time Fellowship and the holder would be able to obtain his master's degree in two years. Address inquiries to R. N. BRACKETT.

Colorado College, Colorado Springs, Colo.—Half-Time Instructorship ($700 and exemption from tuition and laboratory fees but not from breakage fees). In charge of laboratory and demonstration apparatus in general chemistry. Address inquiries to FRANK W. DOUGLAS.

Columbia University, New York City.—Various Fellowships, Scholarships, and Research Assistantships ($500 to $1800). Address inquiries regarding Fellowships and Scholarships to SECRETARY OF COLUMBIA UNIVERSITY and regarding Assistantships to H. C. SHERMAN.

Connecticut Agricultural College, Storrs, Conn.—1 Part-Time Assistantship ($800 and exemption from tuition). Nine hours' laboratory supervision in elementary course. Address inquiries to HOWARD D. NEWTON.

Cornell University, Ithaca, N. Y.—3 University Fellowships ($400–750 and exemption from tuition and laboratory fees); 50 Assistantships ($500–675 and exemption from fees); 1 University Scholarship ($200 and exemption from fees). Address inquiries to L. M. DENNIS.

Duke University, Durham, N. C.—Several Fellowships, Scholarships, and Assistantships. Address inquiries to PAUL GROSS.

Harvard University, Cambridge, Mass.—Several University Fellowships ($400–750). Address inquiries to L. S. MAYO, *Secretary* of the Graduate School of Arts and Science.

A number of half-time Laboratory Assistantships ($850). Holders of such positions must pay a tuition fee of $200 besides fees for breakage and certain materials. Address inquiries to GREGORY P. BAXTER, Coolidge Laboratory.

Holy Cross College, Worcester, Mass.—6 Fellowships ($1000 and exemption from tuition). Maximum of nine hours per week required instructing in either general or inorganic chemistry. Address inquiries to REV. GEORGE F. STROHAVER, S. J.

Indiana University, Bloomington, Ind.—Special Fellowships ($1000–1200), minimum requirement, Ph.D. degree or equivalent; 1 Fellowship ($600); several part-time Assistantships ($400–800); 2 Grasselli Chemical Company Fellowships ($350). Address inquiries to R. E. LYONS.

Iowa State College, Ames, Iowa.—2 Scholarships ($270); 3 Teaching Fellowships ($540); 15 Graduate Assistantships ($700); 3 Research Fellowships ($600 or $700). Address inquiries to W. F. COOVER.

The George Washington University, Washington, D. C.—3 Teaching Fellowships ($600 and exemption from tuition). Address inquiries to COLIN M. MACKALL.

The Johns Hopkins University, Baltimore, Md.—The William H. Grafflin Scholarship ($1000 with exemption from tuition unless student is a candidate for a degree) for independent research in industrial chemistry. Appointment made for two years. The Harry Clary Jones Fellowship in physical chemistry ($1000 with no exemption from tuition or other fees). 1 du Pont Fellowship ($750). Address inquiries to E. EMMET REID.

10 to 12 Assistantships ($650 without remission of tuition or fees). Ten hours work required in undergraduate instruction. Address inquiries to G. H. CARTLEDGE.

8 or 10 University Scholarships ($200–$250). Address inquiries to the REGISTRAR.

Ten State Fellowships ($1000, with no exemption from tuition or fees), open to second-, third-, and fourth-year students. The states in which these Fellowships will be available for 1930–31 are: Kentucky, Louisiana, Michigan, Minnesota, Missouri, North Dakota, Pennsylvania, Virginia, Washington, and West Virginia. Address inquiries to NEIL E. GORDON.

Kansas State Agricultural College, Manhattan, Kans.—Several Graduate Assistantships (at approximately $600). Address inquiries to H. H. KING.

Lafayette College, Easton, Penna.—2 Research Fellowships ($500 and $750); 1 Research Associate ($2500–3500) for investigation of problems connected with plasticity, elasticity, and fluidity. Address all inquiries to EUGENE C. BINGHAM.

Lehigh University, Bethlehem, Penna.—Fellowships giving half-time to research and half-time to graduate study, with exemption from laboratory and other university fees: New Jersey Zinc Co. Research Fellowship ($600); Archer-Daniels-Midland Co. and William O. Goodrich Co.: 4 Fellowships ($900) for research in linseed oil and other drying oils; H. M. Byllesby Memorial Research Fellowship ($750); R. K. Laros Silk Co. Research Fellowship ($800); Barrett & Co. Leather Research Fellowship ($900); Hunt & Rankin Leather Co. Research Fellowship ($900). Foregoing all two-year appointments.

Columbian Carbon Co. Research Fellowship, 12-month appointment, including 4 hrs.' teaching per week ($2400); 2 Student Research Fellowships ($750) open only to Lehigh graduates. Address inquiries to H. M. ULLMANN.

Louisiana State University, Baton Rouge, La.—6 Fellowships ($360), 8 hours of laboratory supervision required; 3 Assistantships ($900), 16 hours of laboratory supervision required. Fellows and Assistants are exempt from tuition and certain university fees. Address inquiries to CHARLES E. COATES.

Massachusetts Agricultural College, Amherst, Mass.—4 Graduate Assistantships ($60 per month), one half-time assisting in laboratory courses required. All fees remitted. Address inquiries to JOSEPH S. CHAMBERLAIN.

Massachusetts Institute of Technology, Cambridge, Mass.—12 Full-Time and Half-Time Assistantships in the various branches of chemistry. Allotments of funds to applicants furnishing evidence of superior scholarship. The Dean's Committee had approximately $6000 in Scholarship Funds available for 1929–30 to assist students in pursuing graduate work. In addition there are eleven Fellowships. Address inquiries to FREDERICK G. KEYES.

Michigan State College, East Lansing, Mich.—6 Half-Time Graduate Assistantships ($800), 2 in physical, 2 in organic, 1 in metallurgy and 1 in biochemistry. Address inquiries to ARTHUR J. CLARK.

Middlebury College, Middlebury, Conn.—2 Graduate Fellowships ($750 and exemption from tuition, laboratory, and breakage fees). Half-time required in laboratory

supervision of general chemistry and qualitative analysis. Address inquiries to P. CONANT VOTER.

Mills College, Oakland, Calif.—2 Trustee Fellowships (expenses of residence and tuition). 1 Amelia Anne Pease Fellowship ($500); 2 Graduate Scholarships open for study in any department. Fellows are expected to devote some time to assisting in their respective departments. Address inquiries to CHAIRMAN OF THE COMMITTEE ON FELLOWSHIPS.

Missouri School of Mines and Metallurgy, Rolla, Mo.—4 Graduate Assistantships ($600 and exemption from laboratory fees). The graduate assistant is limited to two-thirds of a full-time schedule per semester toward a Master's degree. Address inquiries to the DEPARTMENT OF CHEMISTRY.

New York University, New York City, at *University Heights* (*Nichols Laboratory*).—Several Junior Teaching Fellowships ($600 with exemption from fees for three graduate courses); several Senior Teaching Fellowships ($800 with similar exemption). About six new appointments yearly. Address inquiries to ARTHUR E. HILL.

At Washington Square College.—Several Junior Teaching Fellowships ($600 with exemption as above); several Senior Teaching Fellowships ($800 with exemption as above); about fifteen new appointments yearly. Address inquiries to W. C. MACTAVISH.

Northwestern University, Evanston, Ill.—15 Graduate Assistantships ($800–1200); 15 Research Fellowships at ($500–1800); graduate tuition depends upon the number of semester hours of credit carried but does not exceed $150 per year in any case; Research Fellows are exempted from one-half graduate tuition, research chemicals are supplied, charges made for breakage. Address inquiries to CHAIRMAN, DEPARTMENT OF CHEMISTRY.

Oberlin College, Oberlin, Ohio.—1 Grasselli Chemical Company Fellowship ($500 and exemption from tuition and fees); several Oberlin College Fellowships ($500 and similar exemption); 2 Graduate Assistantships ($750 with similar exemption); 2 Scholarships calling for exemption from tuition and fees. Address inquiries to HARRY N. HOLMES.

The Ohio State University, Columbus, Ohio.—13 Part-Time Assistantships ($1000); 34 Graduate Assistantships ($500); address inquiries to W. L. EVANS.

1 special Fellowship ($750); a number of University Scholarships ($300); and University Fellowships ($500), are also open to students in chemistry. All of the above carry exemption from fees (except matriculation of $10) and cost of chemicals. Address inquiries to GRADUATE SCHOOL.

Oklahoma Agricultural and Mechanical College, Stillwater, Okla.—6 Graduate Assistantships ($500 first year and $600 the second year with exemption from tuition and chemical fees). Address inquiries to O. M. SMITH.

The Pennsylvania State College, State College, Penna.—6 to 10 Graduate Assistantships ($800 and exemption from tuition and laboratory fees); 5 to 10 Graduate Scholarships which carry exemption from tuition and laboratory fees; 6 to 9 Research Fellowships requiring no service ($800 to $1500 and exemption from tuition and laboratory fees); 2 to 4 full-time Research Assistantships ($1500 to $1800). Address inquiries to FRANK C. WHITMORE.

Princeton University, Princeton, N. J.—13 Part-Time Assistantships ($650). Address inquiries to N. H. FURMAN.

4 full-time Fellowships ($600–1000). Address inquiries to the DEAN OF THE GRADUATE SCHOOL.

Purdue University, Lafayette, Ind.—8 Teaching Fellowships ($800 plus laboratory

fees and breakage). Preference to men with Master's degree or at least one year of graduate work. Address inquiries to R. B. MOORE.

Rensselaer Polytechnic Institute, Troy, N. Y.—Approximately 3 University Fellowships ($600 and exemption from tuition and all other fees). No teaching required. Address inquiries to THE DIRECTOR.

Rhode Island State College, Kingston, R. I.—6 Undergraduate Assistantships ($100 without exemption from fees). Holders required to assist in laboratory and to correct notebooks and papers to an extent of approximately 200 hours. Address inquiries to J. W. INCE.

Rice Institute, Houston, Tex.—6 Graduate Fellowships ($750 and exemption from all fees). Six hours of laboratory teaching per week required. Address inquiries to HARRY B. WEISER.

Rutgers University, New Brunswick, N. J.—5 or 6 Full-Time Assistantships ($1000). Address inquiries to R. G. WRIGHT.

Smith College, Northampton, Mass.—3 Part-Time Assistantships ($800 for first year and $900 for second, and exemption from tuition and breakage fees). Twenty hours per week required in laboratory supervision and correction of papers. Address inquiries to ELIZABETH S. MASON.

South Dakota State College, State College Station, Brookings, S. D.—Part-Time Assistantship ($600 without exemption from tuition of $80). Eighteen hours' laboratory supervision in general or elementary organic required. Address inquiries to B. A. DUNBAR.

St. Louis University School of Medicine, St. Louis, Mo.—10 Graduate Assistantships ($500–1000, with exemption from tuition). Ten to twelve hours per week of laboratory instruction required. Address inquiries to E. A. DOISY.

Stanford University, Stanford, Calif.—Shell Research Fellowship, endowed by the Shell Development Co. ($900); du Pont Fellowship, endowed by the E. I. du Pont de Nemours Co. ($750); Hammond Lumber Company Research Fellowship, for a study of redwood waste ($1800); American Smelting and Refining Company Fellowship, for investigation of smoke problem ($600); Edward Curtis Franklin Fellowship ($500); Windt Scholarship in Chemical Engineering ($400); John Maxson Stillman Scholarship ($200); 3 Teaching Fellowships ($750); and a number of teaching assistantships (varying in compensation according to the service rendered). Address inquiries to ROBERT E. SWAIN.

The State College of Washington, Pullman, Wash.—5 Teaching Fellowships, requiring 12 to 15 hours per week assisting in the laboratory ($700 first year, $800 the second year), fees nominal. Address inquiries to C. C. TODD.

State University of Iowa, Iowa City, Ia.—3 Scholarships ($200–300); 4 Fellowships ($300–800); 3 Research Assistantships ($600 or more); about 15 Graduate Assistantships ($350); and 16 Assistantships ($700). Address inquiries to EDWARD BARTOW.

Syracuse University, Syracuse, N. Y.—16 Graduate Instructorships ($750–900 with exemption from all fees); a limited number of Fellowships ($500 with exemption from all fees); a limited number of Scholarships which carry exemption from fees. Address inquiries to R. S. BOEHNER.

Trinity College, Hartford, Conn.—2 Part-Time Assistantships ($750, and exemption from tuition, also lodging quarters free). Ten hours assisting in laboratory, five to seven hours preparing for laboratory classes, correcting notebooks, etc. Candidates must have had a minimum of five one-year courses in chemistry. Address inquiries to VERNON K. KRIEGLE.

Tufts College, Boston 57, Mass.—1 Fellowship ($1000 and exemption from tuition);

several Graduate Assistantships ($300, free tuition and free use of apparatus and chemicals). Address inquiries to FRANK W. DURKEE.

Tulane University, New Orleans, La.—1 Part-Time Instructorship ($800); 2 Graduate Assistantships ($450); 2 Student Assistantships ($300); 1 Student Assistantship ($200). All of the above carry free tuition and the remission of laboratory fees in the Graduate School. Address inquiries to H. W. MOSELEY.

Union College, Schenectady, New York.—1 Part-Time Assistantship ($300 and exemption from tuition and all fees). Approximately one-fourth time required for correcting reports and problems in physical and assisting in analytical chemistry laboratory. Address inquiries to EDWARD ELLERY.

University of Akron, Akron, Ohio.—3 Fellowships in rubber chemistry ($1000 with exemption from tuition, fees, and deposits). Nine hours a week required of the holder in laboratory supervision. Address inquiries to H. E. SIMMONS.

University of Alabama, University, Ala.—3 Assistantships ($675); two pure research and one teaching and research. Address inquiries to STEWART J. LLOYD.

The University of Arizona, Tucson, Ariz.—4 Graduate Assistantships ($600 with exemption from tuition and laboratory fees). Twelve to fourteen hours per week required in laboratory supervision, grading notebooks, papers, etc. Address inquiries to CHAIRMAN, DEPARTMENT OF CHEMISTRY.

University of Arkansas, Fayetteville, Ark.—1 or more half-time Assistantships ($600) and 1 or more fourth-time Assistantships ($300). Address inquiries to HARRISON HALE.

University of Buffalo, Buffalo, N. Y.—2 Scholarships ($750 and exemption from tuition). Six to eight hours' teaching required per week. Address inquiries to A. P. SY.

University of California, Berkeley, Calif.—20 Fellowships and Teaching Fellowships. (These positions net about $650 after all fees are paid.) Address inquiries to G. N. LEWIS.

University of Chicago, Chicago, Ill.—1 Fellowship ($1200); 5 Fellowships ($750–900); 5 Fellowships ($400–520); 2 Fellowships ($200–250); 1 Research Assistantship ($960); 2 Research Instructorships ($2400) and one Research Fellowship ($3000) open only to those holding a Ph.D. degree; 4 Assistantships ($810); 5 Assistantships ($510); 5 Junior Assistantships ($410). All students are required to pay the graduate tuition fees of $70 per quarter. This, however, is included in the stipends given above. Address inquiries to JULIUS STIEGLITZ.

University of Cincinnati, Cincinnati, Ohio.—1 Baldwin Fellowship ($500–750) according to qualifications and training of the applicant; 2 Fellowships ($500); 12 Scholarships (free tuition and laboratory fees only). Address inquiries to LOUIS T. MORE, Dean of the Graduate School.

In addition, there are also eight to ten Graduate Assistantships ($600–750, with exemption from tuition and laboratory fees), allotted in the Departments of Chemistry and Chemical Engineering. Address inquiries concerning these Assistantships to H. SHIPLEY FRY, Department of Chemistry or R. S. TOUR, Department of Chemical Engineering.

University of Colorado, Boulder, Colo.—4 Assistantships ($800); 10 Assistantships ($600). Address inquiries to JOHN B. EKELEY.

University of Delaware, Newark, Del.—1 du Pont Fellowship ($300); 2 Part-Time Assistantships. Address inquiries to A. S. EASTMAN.

University of Florida, Gainesville, Fla.—7 Fellowships ($500 and exemption from tuition); approximately 8 Student Assistantships. Address inquiries to TOWNES R. LEIGH.

University of Illinois, Urbana, Ill.—About 15 Teaching Assistantships of two types: half-time ($600) and quarter-time ($300). Address inquiries to ROGER ADAMS.

1 Carr and 1 du Pont Fellowship ($750 each); several University Scholarships and Fellowships ($300, $400, and $500, for first-, second-, and third-year students, respectively). Address inquiries to A. H. DANIELS, *Dean* of Graduate School.

University of Kansas, Lawrence, Kans.—11 Fellowships for graduates of Kansas colleges (1 to each college) ($400); 12 University Fellowships ($400); 11 Part-Time Graduate Assistantships ($400–1000). Address inquiries to H. P. CADY.

University of Louisville, Louisville, Ky.—1 Special Fellowship ($300) for students interested in industrial work; 1 Fellowship ($500) for students interested in physiological chemistry; 3 half-time Assistantships ($500 plus tuition). Address inquiries to A. W. HOMBERGER.

University of Maine, Orono, Me.—2 Teaching Fellowships ($500). Several part-time laboratory assistantships, payment made on basis of time spent in laboratory instruction and in grading laboratory notes. There is also available a fund from which loans can be made to students who have demonstrated marked ability and need some financial assistance. Address inquiries to C. A. BRAUTLECHT.

University of Maryland, College Park, Md.—Several Teaching Fellowships ($500 and $1000 and exemption from tuition but not breakage fees). Two afternoons in the laboratories and 5–6 hours in correcting papers and in preparing reagents required of the holder of a $500 Fellowship. Four afternoons in laboratories and 10 to 12 clock hours in departmental service required of the holder of a $1000 Fellowship. Address inquiries to L. B. BROUGHTON.

University of Michigan, Ann Arbor, Mich.—16 Teaching Assistantships ($800–1000); 1 Lecture Assistantship ($800); 1 du Pont Fellowship ($750); 1 Prescott Fellowship in organic chemistry ($200–400); 1 University Fellowship ($500–600); 1 Scholarship ($200–300). Address inquiries to MOSES GOMBERG.

University of Minnesota, Minneapolis, Minn.—1 du Pont Fellowship ($750); 1 Shevlin Fellowship ($500); 30 Teaching Assistantships ($750 or $650 without one year's previous experience as Assistant). Both laboratory and university fees are remitted to holders of these positions. Address inquiries to S. C. LIND.

University of Mississippi, University, Miss.—3 Fellowships ($300 and remission of all laboratory fees); 6 Student Assistantships which are open to graduate or senior students ($150 per year with remission of laboratory fees). Address inquiries to J. N. SWAN.

University of Missouri, Columbia, Mo.—1 University Fellowship ($600); 1 University Scholarship ($300); 15 Graduate Assistantships ($600–700). Address inquiries to HERMAN SCHLUNDT.

University of Nebraska, Lincoln, Neb.—Several Scholarships ($350–500); several Fellowships ($500–750). All carry exemption from tuition and an allowance for chemicals and breakage. Address inquiries to F. W. UPSON.

University of Nevada, Reno, Nev.—1 Teaching Fellowship ($600). Address inquiries to G. W. SEARS.

University of North Carolina, Chapel Hill, N. C.—3 Teaching Fellowships ($500); 5 Assistantships ($750); 6 Assistantships ($500); 1 Fellowship ($300). Address inquiries to JAMES M. BELL.

University of Notre Dame, Notre Dame, Ind.—5 Graduate Assistantships ($750 each); 2 non-teaching Research Fellowships ($750 plus free tuition); 2 Teaching Fellowships ($1000 each). Address inquiries to HERMAN H. WENZKE.

University of Oregon, Eugene, Ore.—3 Graduate Fellowships ($500 first year, $600 second); 4 Half-Time Fellowships ($25 per month for nine months). Exemption from tuition but from no other fees for both. Twenty clock hours required of full-time

Fellows, ten of half-time. Duties include assisting in laboratory, reading papers, etc. Address inquiries to O. F. STAFFORD.

University of Pennsylvania, Philadelphia, Penna.—Several University Scholarships and Fellowships ($200–1000); 2 Research Fellowships open only to holders of Ph.D. degree ($1500). Address inquiries to H. LAMAR CROSBY.

University of Pittsburgh, Pittsburgh, Penna.—10 Graduate Assistantships ($800 and exemption from tuition fees). Address inquiries to A. SILVERMAN.

University of Tennessee, Knoxville, Tenn.—5 Teaching Fellowships ($500 and remission of all tuition fees except $25, which covers the student activity fee, health and library fees). Address inquiries to CHARLES O. HILL.

University of Texas, Austin, Tex.—27 Tutorships ($725–1400) and Assistantships ($550). Address inquiries to H. R. HENZE.

University of Utah, Salt Lake City, Utah.—5 Teaching Fellowships ($500 without exemption from fees, amounting to about $60). Address inquiries to T. B. BRIGHTON.

University of Vermont, Burlington, Vt.—A number of University Fellowships ($700–800 and exemption from tuition fees). Address inquiries to G. H. BURROWS.

University of Virginia, University, Va.—A number of University Fellowships not specifically allocated to individual departments; 1 Fellowship ($750 and exemption from tuition); 13 Teaching Fellowships ($650–750 and exemption from tuition). Assistance, not exceeding 15 hours per week, in undergraduate courses, required of Teaching Fellows. Address inquiries to SECRETARY, CHEMISTRY FACULTY.

University of Washington, Seattle, Wash.—18 Teaching Fellowships ($720). Address inquiries to GEORGE MCP. SMITH.

University of Wisconsin, Madison, Wis.—3 University Fellowships ($750); 1 du Pont Fellowship ($750); 1 or 2 University Scholarships ($250); 1 Special Scholarship for women only ($300); 4 or 5 Private Research Assistantships ($600); 5 or 6 Senior Assistantships ($1000–1200); 10–15 Junior Assistantships ($600–800). Address inquiries to J. H. MATHEWS.

University of Wyoming, Laramie, Wyo.—2 Graduate Assistantships ($600). Address inquiries to P. T. MILLER.

Vanderbilt University, Nashville, Tenn.—3 Fellowships ($500 and exemption from breakage fees); 3 Scholarships ($300 and exemption from breakage fees). Address inquiries to J. M. BRECKENRIDGE.

Vassar College, Poughkeepsie, N. Y.—1 Part-Time Assistantship ($800 and exemption from tuition). Approximately twenty hours per week required for laboratory supervision, preparations for laboratory and lecture demonstrations, and other departmental work. Address inquiries to MARY LANDON SAGUE.

Virginia Polytechnic Institute, Blacksburg, Va.—3 or 4 Fellowships ($400–$750). Address inquiries to J. W. WATSON.

Washington University, St. Louis, Mo.—6 Assistantships ($750 with exemption from tuition and laboratory fees, and allowance for breakage); 1 Industrial Fellowship ($500 to $750 with similar exemption from fees); several University Fellowships ($500), and Scholarships ($200 with similar exemption from fees). Address inquiries to L. MCMASTER.

Washington and Jefferson College, Washington, Penna.—2 Fellowships ($600 first year, and $750 second year). Address inquiries to A. H. WRIGHT.

Wesleyan University, Middletown, Conn.—From 4 to 6 Half-Time Assistantships ($600 first year, and $800 second year, plus exemption from tuition and charges for breakage); 2 Industrial Fellowships, without teaching duties. Address inquiries to DEPARTMENT OF CHEMISTRY.

West Virginia University, Morgantown, W. Va.—8 Graduate Assistantships

($650); 5 Graduate Fellowships (approximately $500). Address inquiries to FRIEND E. CLARK.

Western Reserve University, Cleveland, Ohio.—1 Jeavons Fellowship ($1200); 1 Cushman Fellowship ($750); 2 Ohio Chemical Manufacturing Company Fellowships ($900); 1 Scholarship ($500). All of these positions carry exemption from tuition and laboratory fees. 3 Assistantships ($200–1000 and free tuition in one graduate course). Address inquiries to E. J. BENTON, *Dean* of the Graduate School.

Williams College, Williamstown, Mass.—2 Part-Time Assistantships ($1200 and exemption from tuition and fees). General assistant work required in general, qualitative, organic, and physical. Address inquiries to BRAINERD MEARS.

Worcester Polytechnic Institute, Worcester, Mass.—2 Part-Time Assistantships ($750 and exemption of one-half of $250 tuition). Supervision required in five three-hour laboratory periods per week. Address inquiries to W. L. JENNINGS.

Yale University, New Haven, Conn.—Several Assistantships ($850–1000, without remission of tuition, laboratory fees and breakage amounting to about $250); several Scholarships and Fellowships that are usually reserved for Ph.D. degree candidates in the final year; the Loomis Fellowship ($1500). Address inquiries to ARTHUR J. HILL.

Tungsten Carbide Cuts "Uncuttable" Metals. Tungsten carbide, the hardest compound known to science, and for years a mere curiosity, has now begun to find extensive commercial use. With it, hard alloys, such as manganese steel and armor plate, can be machined in lathes, planers and shapers, says Dr. Samuel L. Hoyt, of the General Electric Co., in a report to the Engineering Foundation, soon to be published in "Research Narratives."

One of the constituents of this remarkable substance is tungsten, the familiar metal of which the filaments of our electric lamps are made. Though years of research resulted in a process of making tungsten so soft that it could be drawn into fine wires, when combined with carbon it makes a substance second in hardness only to the diamond. Tungsten carbide will scratch a sapphire, which is the second hardest natural mineral.

At first, despite its hardness, tungsten carbide was too porous to stand the strain imposed upon a cutting tool. But researches of Dr. Hoyt and his associates have shown how these difficulties can be overcome. In this form it is known commercially as "carboloy."

"In testing high-speed steel tools," said Dr. Hoyt, "it is customary to use a 'test log,' *i. e.*, a long, round bar of nickel-steel, making a cut in it at about 50 feet per minute. Because of the lack of effect on the carboloy cutter, however, it was necessary to increase the speed to 200 feet per minute. At this speed a high-speed steel cutter failed in 16 seconds, with its edge burned off. The tungsten carbide tool, under identical conditions, was run for an hour before the test was arbitrarily stopped, although the tool was still cutting and capable of continuing for a much longer time.

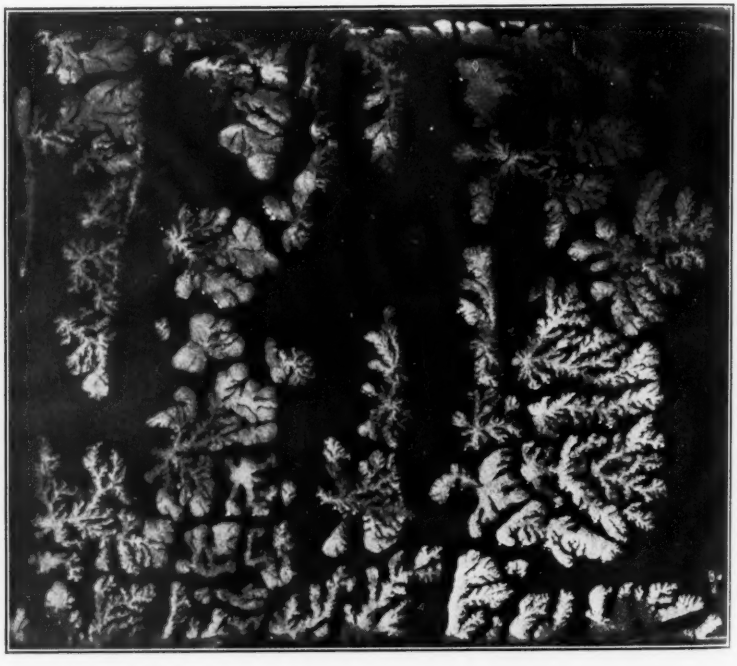
"Consequently, the carbide tool in many operations effects substantial savings of time and costly labor. In others it gets much better results. With it numerous operations are feasible which are not possible with any other known tool material. Nevertheless, the alloys of tungsten carbide have limitations. They will break down, for example, in work involving very heavy pressures on the tools. Carboloy is as yet on the market only to a limited extent although it has been in practical use for the past three years. A great advance in the art of cutting metals appears to be in immediate prospect."—*Science Service*

NOTE ON THE PRODUCTION OF THE "CHEMICAL" MOSS

V. G. Lava and S. B. Etorma, College of Agriculture, University of the Philippines, Laguna, P. I.

In the course of our experiments on the water-proofing and ink-proofing of paper, we have noted an interesting property of stearic acid when used for sizing.

Stearic acid may be incorporated in the paper either from a solution in an ether-alcohol mixture, or from the melted substance, greater uniformity



being obtained by the second method. The paper we used was Yoshimo paper. If this paper, impregnated with the stearic acid, is coated with dilute starch paste containing some coloring material, like toluidine blue, patterns similar to those shown in the accompanying photograph are produced after a short time. In some cases, it is necessary to rub the starch mixture on the treated paper with the finger or a brush in order to obtain the desired pattern.

The Chemistry Student

WHERE CHEMICAL ANALYSES FAIL

GUY BARTLETT, GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

Only because Man in his laboratory has worked more carefully than has Nature in its workshop has it been possible in the past to distinguish between natural and synthetic sapphires, rubies, and other precious stones in the corundum family. Chemical analyses of natural and synthetic stones reveal the same constituents—aluminum oxide, Al_2O_3, with the slight trace of impurity that determines its color and therefore its classification as a precious stone. Chemically the two are alike, but Nature was somewhat slip-shod when it made its jewel—tiny particles of undissolved impurities, minute bubbles within the sparkling gem, or slight flaws between the atomic layers are revealed when a natural gem is examined under a high-powered magnifying glass; Man avoided such imperfections when he synthesized his jewel. In the past, then, the jeweler has depended on his expertness in detecting the minor flaws of Nature in ascertaining the worth of a gem.

While the two types—natural and synthetic—may be the same chemically, they differ in other respects. As gems, for instance, there is a decided difference in the value placed on Nature's and Man's rubies. Simply the fact that the one was dug from the ground makes it worth far more than the other, even though the unaided eye can perceive no difference and even though the expert has difficulty in distinguishing between them with a magnifying glass.

In industry as well, the relative values of the two kinds of stones differ. The natural stone, with a better wearing surface, is preferred for jewel bearings. Even in the case of natural stones there is a difference in wearing quality, but it has been even more difficult for the expert to distinguish between natural stones from one country and those from another.

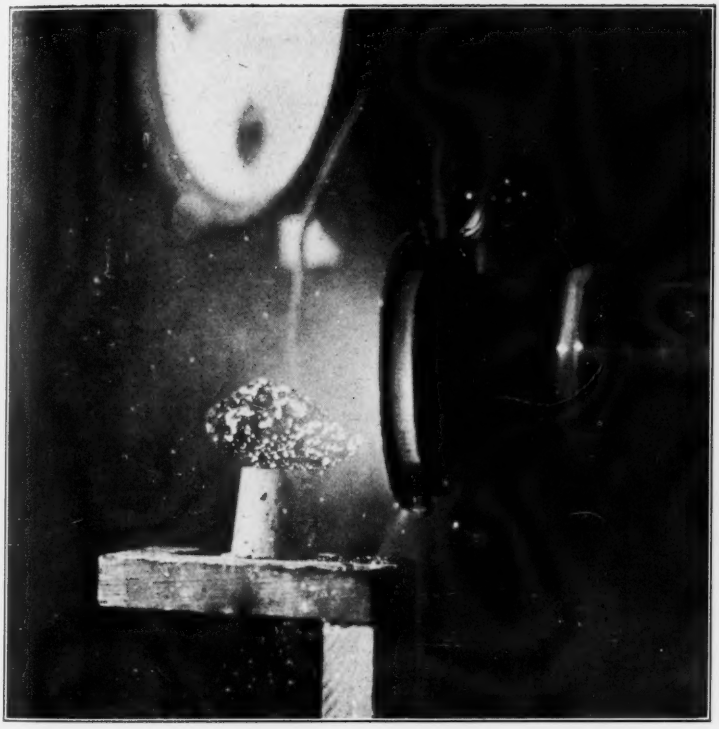
Now, however, there has been devised a method for quickly and accurately distinguishing between synthetic and natural stones; between natural stones from different countries; and, in some cases, even between synthetic stones from different factories. The device which does this is the powerful cathode-ray tube developed by Dr. W. D. Coolidge of the General Electric Research Laboratory three years ago.[1] The use of the tube in this work is its first commercial application.

More than a million and a half sapphires, next below the diamond in the

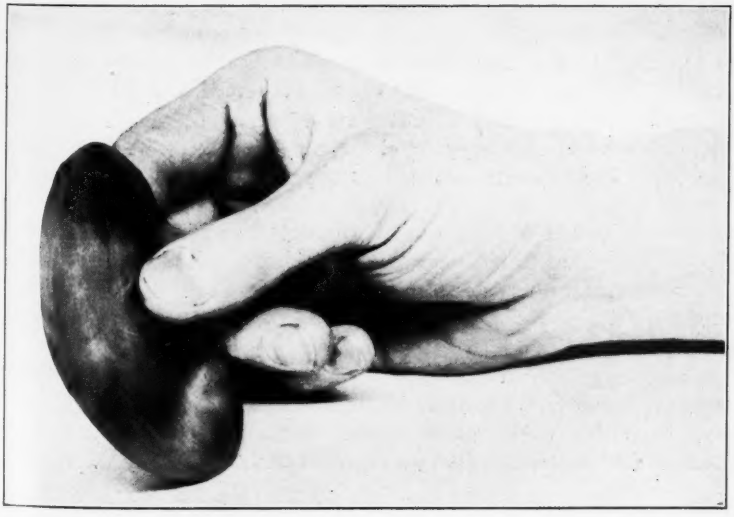
[1] "The Cathode-Ray Tube—A New Chemical Agent" was described in THIS JOURNAL, **3**, 1369–79 (Dec., 1926).

PLACING A TRAY OF MIXED NATURAL AND SYNTHETIC SAPPHIRES BEFORE THE CATHODE RAY TUBE

scale of hardness, are used by the General Electric Company each year as jewels for bearings in meters and other delicate electrical instruments. If a tray of mixed stones is exposed, in a dark room, to the rays of the tube for a few seconds it will be noticed that all of the stones are luminescent, glowing with different hues. When the rays are turned off, however, a decided difference is at once apparent. The synthetic stones are phosphorescent, and continue to glow, while the natural stones cease to radiate



MINERAL SUBJECTED TO CATHODE RAYS, SHOWING LUMINESCENCE



THIN METAL FOIL WINDOW OF CATHODE RAY TUBE, THROUGH WHICH ELECTRONS ESCAPE WITH A VELOCITY OF 150,000 MILES A SECOND

A COLLECTION OF NATURAL AND SYNTHETIC SAPPHIRES TO BE IDENTIFIED BY THE CATHODE RAY TUBE

colors. And, by the color of the radiation and the duration of phosphorescence, it is possible to determine the source of the stone.

"Should sapphires from Montana be mixed with stones which were supposed to come from Australia or Ceylon, for instance, we could determine the fact readily with cathode rays," says B. W. St. Clair of the standardizing laboratory of the company at Lynn, Massachusetts, where the tests are conducted. "In the case of synthetic stones it is usually possible also to determine which factory made them by the different hues of the glow while the rays are on. We have one particular kind of natural sapphire which does not glow; in this case the absence of hue serves to reveal its origin."

Some tests have been made with diamonds, and it has been found that imitation stones turn decidedly brown when placed in the rays, whereas there is no change in genuine stones. These tests have been meager, however, and definite conclusions have not been reached by the General Electric scientists.

CARBON DIOXIDE. II. ITS INDUSTRIAL APPLICATION

ELTON L. QUINN, UNIVERSITY OF UTAH, SALT LAKE CITY, UTAH

The birthday of the carbon dioxide industry is considered, by many, to be Aug. 28, 1879. On this date, Dr. W. Raydt, in Germany, attached a deflated balloon to an anchor on the bottom of the sea, in Kiel harbor, inflated it with carbon dioxide gas, and in just eight minutes had raised the anchor to the surface of the ocean, a distance of 10 meters. Then Raydt tried to raise some sunken steamers, but finally turned to the use of carbon dioxide for raising beer and for making soda water. The anchor episode, while of no great importance in itself, did turn the eyes of many inventors and scientists to the compound responsible for it, and from this time on, carbon dioxide received a great deal of attention as a potential article of commerce. Five years later, Raydt had established a factory for the production of liquid carbon dioxide, and part of the product from that factory was used by the Krupp Iron Works for compressing liquid iron into the molds. Raydt's factory became of great economic importance in later years, and this fact, more than the experiments with the anchor, gives him the place as father of the industry. Many other workers were studying the properties and methods of manufacturing liquid carbon dioxide at this time and we find among them the names of Hill and Beins, whose contributions to the industry are worthy of mention here.

In the year 1877, Dr. Hendryk Beins in Groningen took out his patent on the production of liquid carbon dioxide by heating sodium bicarbonate. He was interested in the liquid, which he called "carboleum," as a motive power. In his discussion of the advantages of "carboleum" over other forms of power, Beins said: "It can be used: (1) for locomotives; (2) for steam boats; (3) for small factories such as sewing machines, pumps, and lathes; (4) in fire extinguishers as gas or solution; (5) as a source of power for electrical machines for street lighting, lighthouses, telegraphs, etc.; (6) as a 100 times cheaper projectile propeller than powder; (7) in the accomplishment of scientific under-sea navigation for war purposes and perhaps for operating air ships; (8) for ice machines; (9) for mineral water as well as a source of pure carbon dioxide."

Beins' experiments with carbon dioxide as a propelling medium for submarines interested the Dutch Navy to such an extent that the Minister of Marine, after an intelligent official test, which found it feasible, furnished financial assistance for carrying out the project.

About the same time, an American, Walter Hill, working at the Naval Station at Newport, R. I., experimented with liquid carbon dioxide as a motive power for propelling and steering torpedoes. In 1873 the Navy Department purchased a "Lay Torpedo" with the Lay apparatus for producing the carbon dioxide. This apparatus Hill found to be faulty, a condition which he set about to remedy. In a few years he had developed

a very successful plant for the production and liquefaction of carbon dioxide. After many difficulties in obtaining containers capable of withstanding such high pressures, he was able to manufacture and compress 700 pounds of this liquid, which he made at the rate of about 46 pounds per hour. The generator of his plant made use of the reaction between marble dust and sulfuric acid for producing the carbon dioxide.

It seems from the records that Hill mastered the difficulties connected with the manufacture and storage of liquid carbon dioxide, but had little success with its application as a motive power for torpedoes. His labors were not wasted, however, as the carbonated beverage industry stood ready to profit from the results of his efforts.

Soda water had been made in this country before 1873, but only from carbon dioxide made at the point of consumption, by means of generators charged with sodium bicarbonate or marble dust and sulfuric acid. About this time attention became directed to the use of the liquefied compound, and gradually, as the machinery for compressing and the cylinders for storing became available, the use of the generators decreased, until today it is an unusual sight to see one of the old-time generators taking up space in a soda water plant.

The Soda Water Industry

The Beginning of the Industry.—The soda water industry had its origin in the naturally carbonated waters found in nature. It has developed very gradually from the time when a few plants tried to make, artificially, water similar to that found in certain mineral springs, up to the present time when practically every city in this country has several bottling plants. In the beginning, water was carbonated to imitate the famous waters from Pyrmont, Germany, Apollinaris water from a spring in the Valley of Aar, near the Rhine, as well as Vichy water and some others. Then flavoring and sweetening materials were added, and in most cases coloring matter, and the carbonated beverage industry was well on its way. Many of us remember the country grocery store with its box of soda water bottles from which one could select either "strawberry," "lemon," or "sarsaparilla." The "strawberry" was crimson with cochineal and flavored with a mixture of nitrous ether, chloroform, ethyl acetate, and oil of wintergreen. The "lemon" was flavored with a very dilute solution of lemon oil, while the "sarsaparilla" was flavored with oil of sassafras and colored with caramel. Fortunately, these materials were present only in small quantities, while the more wholesome carbonated water constituted the bulk of the drink. Today we find a large assortment of flavoring materials, some of which are the products of synthetic chemistry, while others are obtained from concentrated fruit juices and other natural sources.

Carbonated Water.—As we have already said, the bulk of all carbonated drinks is water saturated with carbon dioxide under a pressure that may run as high as 100 pounds per square inch, although more moderate pressures are the rule. When the pressure of the gas above the liquid, carbonated under pressure with very pure carbon dioxide, is suddenly released by opening the bottle or drawing the carbonated water from a fountain, there remains a super-saturated solution of carbon dioxide which gives up its excess gas slowly and retains for some time that delightful flavor characteristic of carbonic acid.

The Process of Carbonating Water.—The chemical and physical problems connected with the carbonation of water are rather simple and mechanical devices that produce carbonated water automatically saturated at any desired pressure and in any quantities are now in everyday use. The modern carbonator is a tin-lined tank having a pump for injecting the water against any desired pressure of gaseous carbon dioxide. This gas comes from a cylinder of the liquid, the pressure being reduced to the proper value by means of a reducing valve. The carbon dioxide and water in the carbonator are brought into intimate contact, either by mechanical agitation of the liquid or by spraying the water into a space containing the carbon dioxide. Such machines will operate practically without attention for long periods of time, delivering water, properly carbonated, to the bottling machine, or soda water fountain.

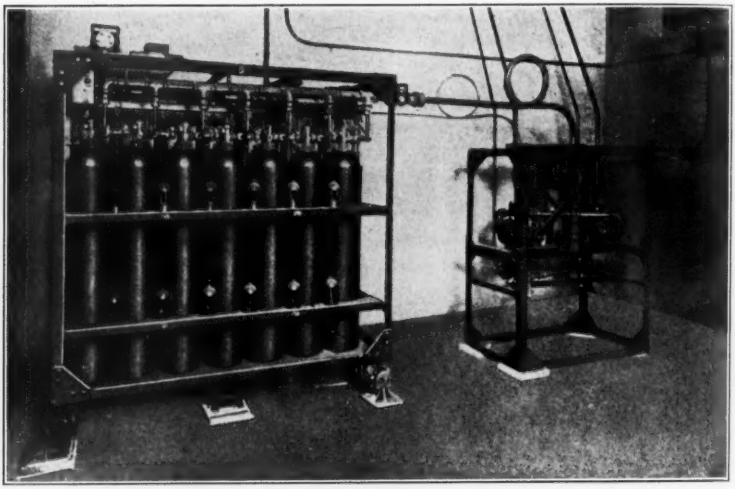
Stupendous amounts of carbon dioxide are used in the bottling industry, and from the standpoint of quantity used, this is by far the most important commercial usage to which this gaseous compound is put.

As a Fire Extinguisher

Using a Solution of Carbon Dioxide.—Carbon dioxide is, and always has been, second only to water as a fire extinguisher. The familiar automatic carbon dioxide generator, in which the gas is made from sodium bicarbonate and sulfuric acid, still holds its own, notwithstanding the more modern means of fire fighting. These extinguishers adorn the walls of most laboratories and their efficiency in case of emergency is very well known to most laboratory workers.

Larger units, operating on the same principle as the hand extinguisher, are often put on wheels so they can be moved quickly to the place of need in an industrial plant. The familiar chemical apparatus of the city fire department is a still larger unit in which carbon dioxide is made in substantially the same way.

The writer once saw a fire extinguished in a summer resort hotel at Peakes Island, Maine, by means of carbon dioxide from tanks containing carbonated water. These tanks were intended for the corner drug store fountain and stood on the sidewalk in front of the hotel. Some inspired



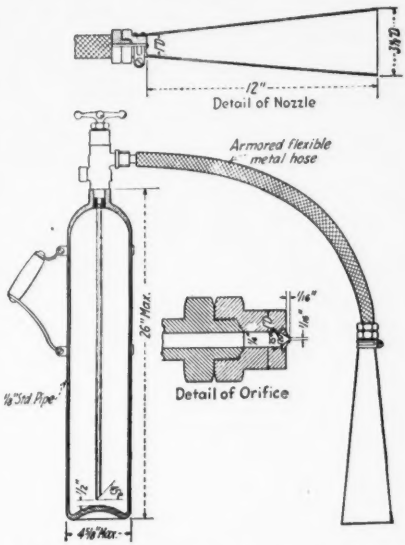
LUX SYSTEM FOR EXTINGUISHING ELECTRICAL FIRES, SHOWING THE CYLINDER BATTERY AND DELAYED GAS RELEASE AND ELECTRICAL DISTRIBUTING VALVES

genius, at the beginning of the fire, pulled up one of the tanks and discharged its contents into the flames with such success that several other tanks were quickly used and the fire was promptly extinguished.

The Use of Dry Carbon Dioxide Gas.—Dry carbon dioxide gas, obtained from cylinders of the liquid, is often used as a fire extinguisher. The "Lux System" for distributing this gas to the burning area is exceptionally efficient and has found wide use in protecting electrical machinery and boats of all sizes. In this device, the gas is supplied to the fire by means of a permanent piping system, connected to one or several tanks of liquid carbon dioxide. The carbon dioxide can be turned on automatically by the heat of the fire, or by a hand control, and it quickly floods the burning room with gas, in which combustion is not possible. The cylinders containing the liquid carbon dioxide are usually placed on the platform of a scale and this is provided with an automatic electric alarm system, so arranged that when the gas is turned on, the alarm is sounded. The most novel feature of this system is the manner in which the liquid carbon dioxide is liberated from the cylinders and conducted to the seat of the fire, where it is expanded into a gas. In the case of electric generators, motors, transformers, etc., dry carbon dioxide is especially effective. No better means for combating such fires have ever been discovered. This gas is a non-supporter of electricity; it leaves no residue; it is non-injurious to all substances; it will not freeze or deteriorate; and can be obtained

almost anywhere. Overheated generators or motors can be shut down, and by means of a blanket of carbon dioxide, combustion can be arrested until the machine has cooled below the ignition temperature. The gas can then be quickly removed by simply opening the windows.

The Use of Foams.—Fires occurring in open spaces or in any place where a large draft of air is produced by the blaze, cannot be so successfully extinguished with dry carbon dioxide gas. The dilution of the gas by the inrushing air prevents its action on the flames. It is possible, however, to prevent the mixing and escape of the carbon dioxide by inclosing it in bubbles of a liquid in the form of a foam. The foam stabilizer most often employed is an extract from licorice root and is known as "firefoam liquid." The carbon dioxide is usually made in a ' Foamite" fire extinguisher. The solutions in this extinguisher have the following composition: The first, 11 parts aluminum sulfate and 89 parts water; the second, 8 parts sodium bicarbonate, 3 parts firefoam liquid, and 89 parts water. On mixing these solutions a tough, durable foam, which resists heat and mechanical abuse, is produced. This method of attacking fire has proved decidedly valuable in the protection of oil tanks and is now almost universally used for this purpose.



FIRE EXTINGUISHER FOR THROWING SOLID CARBON DIOXIDE

Designed by C. L. Jones for extinguishing electrical fires, especially for protecting telephone switchboards.

For Mine Fires.—The application of gaseous carbon dioxide to mine fires has received considerable attention in recent years. The results obtained, however, have varied all the way from flat failures to complete successes. It seems that under certain conditions and with intelligent application carbon dioxide can be used successfully for this purpose. Its function, however, is not the same as in the case of other fires. Due to the very large amount of air in a coal mine it would be difficult to add enough carbon dioxide to make the whole atmosphere a non-supporter of combustion. Its best service perhaps is in adjusting changes of pressure within the sealed-up mine, for the purpose of preventing fresh air from being

sucked in, thus permitting the fire to be smothered by its own products of combustion.

The Use of Solid Carbon Dioxide.—The use of solid carbon dioxide as a fire extinguisher has certain advantages not possessed by the gaseous substance. It has a sublimation temperature of about 78 degrees below zero Centigrade, at which temperature it changes to a gas, thereby absorbing much heat. Besides the cooling effect this has on the fire, the gaseous carbon dioxide produced from the solid extinguishes the flame by its usual smothering effect. Such an extinguisher is very simple. It consists of a small steel carbon dioxide cylinder having a siphon tube extending from the valve to the bottom of the cylinder so that when the valve is opened, the liquid carbon dioxide is ejected from the cylinder with great force through a flexible tube which serves to direct the stream. A special nozzle on this tube permits the liquid to expand suddenly into the gaseous form, thereby absorbing enough heat to freeze a large part of it. A special shield on this nozzle prevents, to a certain extent, the stream of solid and gaseous carbon dioxide from carrying air along with it. The cooling action of the solid carbon dioxide plays no small part in its effectiveness. This extinguisher is portable, is always ready for use, and has found a useful place in protecting electrical apparatus, especially telephone switchboards.

The Medical Uses of Carbon Dioxide

Carbon dioxide in the rôle of life-saver and alleviator of pain is something hard for most of us to understand. The numerous cases on record, where this gas has been the cause of death, make it difficult for us to visualize it as a part of a modern hospital equipment, as we find it today. Not only hospitals, but police departments, fire departments, and industrial concerns, such as electric light companies and gas companies, have very urgent need for this compound at times.

For Stimulating Breathing.—The theory seems to be pretty well accepted now, that carbon dioxide is the stimulating agent to the respiratory center which causes the organs of respiration to adjust themselves automatically to various rates of metabolism. If this is true, then it should be possible to artificially stimulate respiration by administering carbon dioxide to the lungs. It has been proved beyond all doubt that this can be done, providing small concentrations (less than 10%) of the gas are used. Concentrations above 10%, however, have a narcotic effect which, due to its paralyzing action, slows down the respiration rate. Not so many years ago the failure of the "mirror test"[1] to indicate breathing was sufficient for some physicians to pronounce the patient dead, but such is not the case today. Suspended respiration, due to electrical shock or drowning, is not

[1] A mirror held to the mouth of the patient, the presence of moisture on the mirror indicating breathing.

Courtesy Mine Safety Appliance Company

SHOWING THE ADMINISTRATION OF A CARBON DIOXIDE-OXYGEN MIXTURE WITH AN H-H INHALATOR AND THE SCHAEFER PRONE PRESSURE METHOD OF ARTIFICIAL RESPIRATION

considered very serious, providing the patient is otherwise in a healthy condition and intelligent aid is given immediately. To start the breathing, however, artificial respiration or some mechanical device for producing the same effect may be necessary. Instead of air, a 5 per cent carbon dioxide, 95 per cent oxygen mixture, sometimes called "carbogen," is forced into the lungs. The stimulating effect of the carbon dioxide, together with the ventilation produced by the oxygen is a wonderful aid in starting natural breathing again. A machine for administering this mixture of gases is called an inhalator or a resuscitator, the latter term being applied more especially to the machine which forces the mixture into the lungs and the former, one which simply supplies the proper gas mixture for the patient to use, by natural breathing or by the Schaefer manual prone pressure method of artificial respiration. There are many cases where such inhalators are especially useful, such as carbon monoxide poisoning, the inhaling of smoke, gas, petroleum vapors, benzol and other poisonous gases, electric shock, drowning, acute alcoholic intoxication, morphine narcosis, pneumonia, asphyxia in the new-born, and suspended respiration from other causes.

Courtesy Mine Safety Appliance Company

RESUSCITATION OF VICTIMS OF A STEAMER DISASTER ON LAKE MICHIGAN SHOWING THE MEMBERS OF THE COAST GUARD USING A CARBON DIOXIDE-OXYGEN MIXTURE IN AN H-H INHALATOR

As an Aid in Anesthesia.—Carbon dioxide as an aid in inducing anesthesia with ether, nitrous oxide, or ethylene and to aid in the removal of the anesthetic when it is no longer needed, is fast becoming general hospital practice. Henderson, Haggard, and Coburn[2] have made a very complete study of this subject. At first, all authorities did not agree as to its beneficial aspects, but now it is quite generally accepted as being of great value when properly administered. Lundy[3] reports on 1350 cases where carbon dioxide was used during anesthesia at the Mayo Clinic, Rochester, Minnesota. The advantages gained by the use of this gas during induction and maintenance and at the termination of anesthesia are given by Lundy as: (1) An increase in the rate of absorption of ether, when it is used alone or with other anesthetic agents, by increasing the volume of respiration. (2) Low concentrations of ether vapor. (3) Reduction of struggling, breath-holding and shallow breathing, and the absence of cyanosis. (4) Greater relaxation in light anesthesia. (5) The quieting effect of mor-

[2] Henderson, Haggard, and Coburn, *J. Amer. Med. Assoc.*, **74**, 783–6 (1920).

[3] Lundy, *Ibid.*, **85**, 1953–5 (1925).

phine, without its occasional bad effect on the respiratory center. (6) The starting of respiration in the new-born infant without the usual vigorous manipulations, if the air passages are clear. (7) Better prognosis if patients are moribund from operative procedures or for other reasons. (8) A lack of idiosyncrasies to low concentrations (3 per cent). (9) A safer induction and maintenance of gas anesthesia in children. (10) The hastening of the elimination of ether and revival of the patient.

Other Clinical Uses.—The employment of carbon dioxide gas for the control of hiccoughs is now quite common. Hiccoughs often develop after an operation and unless they can be stopped the patient may die because of the terrible racking produced in the body. The gas is administered in high concentrations, sometimes as pure carbon dioxide, one or two inspirations, in most cases, being sufficient to stop them.

The latest development in the possible clinical use of carbon dioxide comes from the medical school of the University of California where insane patients afflicted with the type of insanity known as *dementia praecox catatonia* have been treated, by inhalation, with carbon dioxide. In practically all cases so treated, there was a fleeting return of intelligence. Also, the use of carbon dioxide for the redistention of the lungs after collapse has recently been shown to be possible.[4] This collapse may be due to surgical operation and is a stage or factor in the development of pneumonia. How far either of these uses will go toward relieving human suffering remains to be seen, but it is quite satisfying to know of the progress being made.

Solid carbon dioxide has been employed, in the past, quite extensively in dermatology. Recently, however, its popularity has waned somewhat, because of the large number of other substances which may be used for the same purpose although it is still used at times as an escharotic or cauterant.

The refrigerating properties of liquid carbon dioxide are employed in the hospital laboratory for freezing tissues. In the frozen condition these tissues are readily cut into sections for microscopic study. This procedure is so rapid that it can be used to aid the surgeon, during an operation, to distinguish between healthy and diseased tissues.

As a Source of Power

While one can hardly hope to operate steam boats or air ships profitably with carbon dioxide as the motive power, as was suggested by Beins, there are numerous places where it can be used to advantage. The carbon dioxide cylinder is the cheapest portable source of high pressure that we have, and it finds many uses, such as operating paint-guns, tree-spraying devices, blowing obstructions from plumbing, operating pneumatic jacks, filling automobile tires, and many other purposes.

[4] Henderson and Haggard, *J. Amer. Med. Assoc.*, **92**, 434–6 (1929).

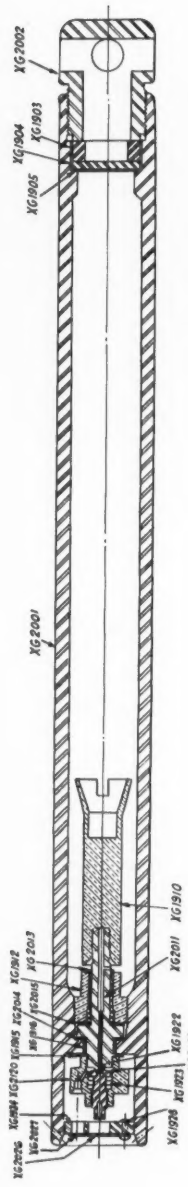
Courtesy of the E. & J. Manufacturing Co.

HOSPITAL TYPE OF ANESTHESIA APPARATUS BY MEANS OF WHICH CARBON DIOXIDE CAN BE USED FOR INDUCTION AND TERMINATION OF ANESTHESIA. THIS APPARATUS ADMINISTERS NITROUS OXIDE, ETHYLENE, ETHER, OXYGEN, AND CARBON DIOXIDE IN ANY PROPORTIONS

Courtesy Safety Mining Company

SHOWING THE METHOD OF LOADING THE HOLE WITH A CARDOX CARTRIDGE FOR BLASTING DOWN COAL

The "Cardox" System of Coal Mining.—One of the newest developments along this line is the "cardox" system for mining coal. In the "Cardox" method, liquid carbon dioxide is charged into steel cartridges by a small compressor at the mine. The discharge end of the cartridge is equipped with a small renewable steel disk which shears at some predetermined pressure, which is more than 10,000 pounds per square inch. A renewable heater element, ignited by an electric current, generates sufficient heat to vaporize the liquid carbon dioxide. The heat generated increases the internal pressure until the ultimate strength of the disk is exceeded and it shears. The gas passes into the drill hole and its expansion to atmospheric pressure breaks out the coal without the shattering effect of an explosion. The release pressure of the gas is regulated by the thickness of the disk employed, thus fixing within control of the management the exact pressure exerted upon the coal. The quantity of gas in each shell is also fixed at the charging plant, so that the strength of each charge is accurately controlled. Holes for the cartridges are drilled with standard post-mounted electric drills cutting a cored hole. The discharge end of the cartridge is inserted in the shot-hole first. Insulated firing cables are connected to the terminals. The cartridge is pushed to the back of the hole, tamped, and discharged by an electric current. Shells are recovered and re-used indefinitely.



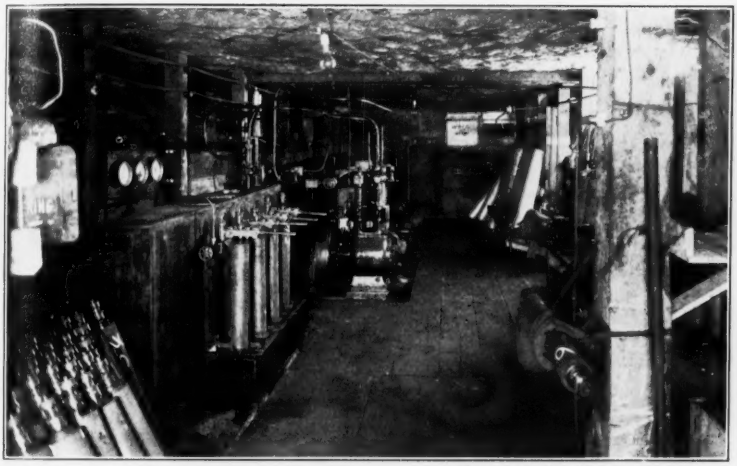
Courtesy Safety Mining Company

DETAILS OF A CARDOX CARTRIDGE

XG2001—Shell
XG2002—Discharge cap
XG1903—Shear ring
XG1904—Replaceable disk
XG1905—Fiber gasket
XG1910—Heater support
XG2011—Electrode
XG1912—Electrode nut
XG2013—Electrode nut insulator
XG2014—Sealing washer
XG1915—Valve cap washer
XG2015—Electrode nut washer
XG1916—Electrode insulator
XG2120—Valve cap
XG2021—Valve stem
XG1922—Copper valve seat
XG1923—Leather packing (3 pieces per shell)
XG1924—Protector disk
XG2026—Protector disk cover
XG2027—Protector disk cover
XG1928—Rivets $^3/_{16} \times {}^1/_2$

This method of blasting down coal has many advantages over the usual use of explosives. The reduction of hazard to the miner is, of course, the most important advantage. This is due principally to the fact that it is unnecessary to handle explosives, for the "cardox" cartridge is considered a blasting device and not an explosive. During the discharge of the carbon dioxide from the cartridge no dangerous gases are given off, and the amount of carbon dioxide added to the atmosphere of the mine is not sufficient to raise its concentration anywhere near the danger point. The absence of flames during the blasting is perhaps of the greatest importance, since it eliminates all danger of igniting coal dust or methane gas in the mine. Besides the advantages due to safety, a much better grade of coal is produced and the fact that the miners need not leave the mine during the blasting process is a matter of no small economic importance.

For the Sportsman.—One carbon dioxide enthusiast, known to the author, carries a small cylinder of this substance in his automobile. He often goes duck hunting and if he happens to have a flat tire on the way, he takes out his pneumatic jack and uses the carbon dioxide to lift his car. Then he repairs the tire and fills it from the cylinder of gas. When he arrives at the hunting ground he inflates his rubber boat



Courtesy Safety Mining Company

AN UNDERGROUND CHARGING STATION, SHOWING HOW THE CARBON DIOXIDE IS CHARGED INTO THE CARDOX CARTRIDGES

with carbon dioxide and if he sleeps out, he fills his air mattress with the same substance. It is possible that on his return he recounts his hunting experiences to his friends over a glass of root beer made by means of a siphon bottle which he charges from his magic cylinder. It seems as if the only thing at present lacking will be supplied when some one develops the explosive power of this liquid so it can be used for shooting the birds.

As a Refrigerant

Liquid Carbon Dioxide in Refrigeration.—The use of carbon dioxide as a refrigerating agent is not new. For many years it has held its own in certain types of refrigerating plants, especially on board ships or other places where ammonia or any other refrigerant might constitute a hazard. Its disadvantage lies in the much higher pressures necessary for its liquefaction and because of this fact it does not seem to have a place in the small household refrigerating machines which are so popular now.

Solid Carbon Dioxide as a Refrigerant.—Without doubt, the most spectacular advancement in the application of carbon dioxide that has ever taken place is happening at the present time in the phenomenal development in uses and methods of manufacture of the solid state. For many years, solid carbon dioxide has been made on the chemistry lecture table for the edification of students in general chemistry and in the research laboratory for low temperatures. Now it is being made on a large scale by many plants, some of which are capable of producing as high as forty

tons per day. The total combined daily capacity of nine plants located mostly in or near New York City is over 119 tons.

When liquid carbon dioxide is expanded into a gas, the heat of vaporization must be taken from the liquid and its surroundings. This absorption of heat rapidly lowers the temperature of the carbon dioxide until some of it freezes into very small white snow-like crystals. With a filtering device such as a piece of cloth, the solid may easily be separated from the gas. In former times, this was usually accomplished by placing the cylinder containing the liquid carbon dioxide on a table, elevating the bottom so the liquid would collect at the valve end and letting the liquid out into a canvas bag. Large quantities of the snow could be prepared by this process but it was necessary to waste a very large part of the carbon dioxide in its preparation. Under the best of conditions, such as a very cold cylinder of carbon dioxide, only about one-third of the liquid could be converted into the solid state. It is obvious that the efficiency of the process depends upon the initial temperature of the liquid, and the lower this temperature the higher the yield of snow. At the critical temperature or above, no solid can be produced.

Laboratory Methods for Producing the Solid.—Modern devices for the production of solid carbon dioxide eliminate much of the trouble formerly experienced in lifting the cylinder about and now it is about as easy to get a supply of carbon dioxide snow as to get a supply of ordinary ice.

In one form of apparatus for the production of solid carbon dioxide the cylinder is held bottom up in a specially designed frame and is connected to the freezer through a drying tower. Small blocks of the solid can be made easily and quickly by this process. However, placing a carbon dioxide cylinder in this position is apt to cause considerable trouble at times, due to the scale from the inside of the cylinder obstructing the valve. This scale is practically always present in carbon dioxide cylinders, due to the action of the carbonic acid on the iron. Better results can be obtained by inclining the cylinder at an angle so the scale will collect in the top of the cylinder before it reaches the valve.

Another type of laboratory apparatus for producing solid carbon dioxide makes use of a siphon cylinder which can be operated in a vertical position and right side up. A small iron tube screwed into the brass valve extends nearly to the bottom of the cylinder and this brings the liquid up to the valve where it is conducted through a small copper tube to the freezer which is clamped onto the top of the cylinder. Drying is not necessary in this case as the liquid water collects in the bottom of the tank and is not drawn off, while the dissolved water causes no trouble. The snow collects in small paper cups about 8 cm. in diameter by 2 cm. deep, and is so hard that it requires force to break the blocks into small pieces for use. The most important advantage of this type of freezer is the ease of operation and the

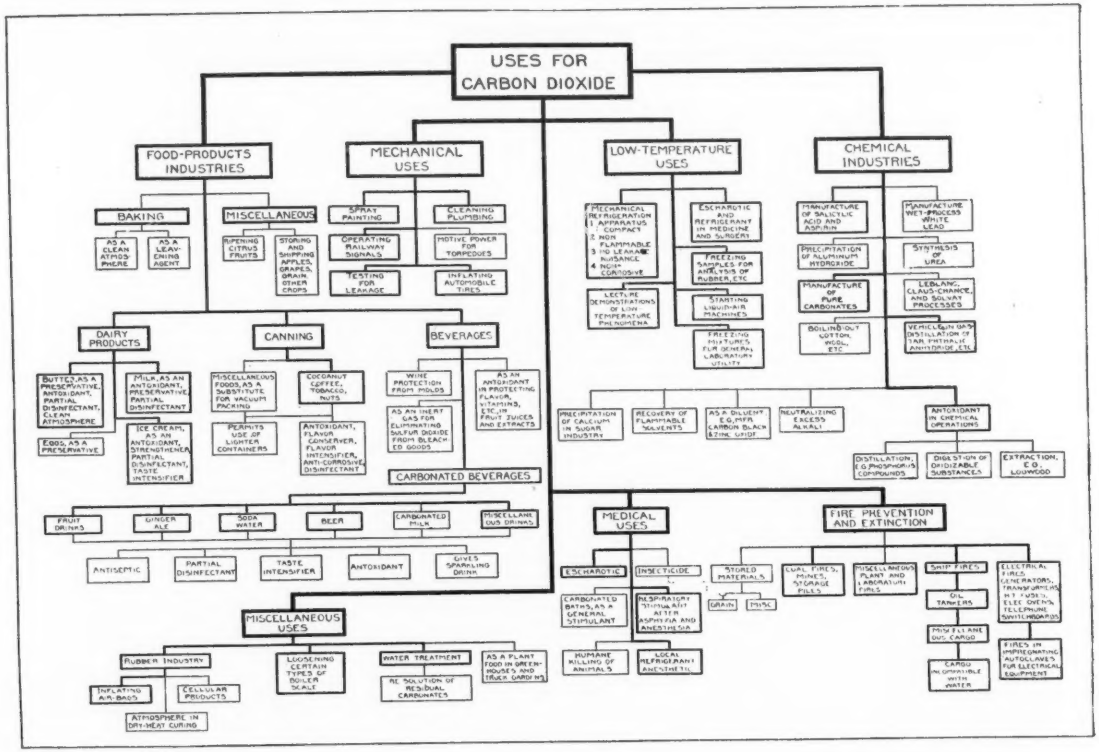
control one has over the amount produced. One gram of the solid can be made about as easily as one whole block. It has the disadvantage that siphon cylinders cannot always be obtained and also that some liquid always remains in the bottom of the cylinder out of reach of the siphon tube.

The Commercial Method of Producing Solid Carbon Dioxide.—The commercial production of solid carbon dioxide is carried out in essentially the same manner as the laboratory production. The liquid carbon dioxide from the condensing system of the plant is cooled by mechanical refrigeration, usually with a carbon dioxide refrigerating machine. The cooled liquid is expanded into the inner compartment of a double-walled cylinder; the solid is retained in the inside cylinder because of a cover of canvas and the cold gas escapes, passing around this inner cylinder on its way back to the compressor where it is again liquefied and goes through the cycle once more. This inner cylinder has a capacity of about 500 pounds of the solid and when it is full, a fact that can be determined by weighing, it is opened and the white solid is shoveled into molds. The carbon dioxide snow is tamped into the molds and then subjected to a pressure of 500 pounds per square inch by means of a hydraulic press. The finished block is about $10 \times 10 \times 10$ inches and weighs about 40 pounds. It is then wrapped in heavy paper and is ready for the market. With this arrangement, the yield of snow is about 40 to 50 per cent of the liquid expanded and it requires about 20 minutes to make 500 pounds of it.

The Commercial Uses of Solid Carbon Dioxide.—Due to the fact that the temperature of solid carbon dioxide is 109 degrees below zero, Fahrenheit, and that it changes directly from a solid to a gas without passing through the liquid state, there are many special applications to which it may be put. Because it does not melt to a liquid it is often called by the trade name of "dry ice." A certain frozen confection is dispensed from vacuum jugs, the inside temperature of which is kept satisfactorily low with one pound of this refrigerant per day. Ice cream, meat, and fish are being distributed in trucks refrigerated with solid carbon dioxide. Food specialties are being shipped regularly over long distances in specially designed containers.

The Laboratory Uses of Solid Carbon Dioxide.—The laboratory uses of solid carbon dioxide, in practically all cases, depend upon the low temperatures which it produces. Ether is usually added in order to produce a semifluid mass which makes excellent contact with the object to be cooled. The ether changes the sublimation temperature of the solid only a negligible amount (0.008°C.) and constitutes only 0.065 mol per cent of the vapor.[5] It acts, therefore, as an indifferent substance and has practically no effect on the vapor pressure of the solid carbon dioxide. The temperature of this solid, however, can be controlled by simply changing the pressure of the

[5] Thiel and Schulte, *Z. physik. Chem.*, **96**, 328 (1920).


USES FOR CARBON DIOXIDE
FOOD-PRODUCTS INDUSTRIES
BAKING
AS A CLEAN ATMOSPHERE
AS A LEAVENING AGENT
MISCELLANEOUS
RIPENING CITRUS FRUITS
STORING AND SHIPPING APPLES, GRAPES, GRAIN, OTHER CROPS
DAIRY PRODUCTS
BUTTER, AS A PRESERVATIVE, ANTIOXIDANT, PARTIAL DISINFECTANT, CLEAN ATMOSPHERE
MILK AS AN ANTIOXIDANT, PRESERVATIVE, PARTIAL DISINFECTANT
EGGS, AS A PRESERVATIVE
ICE CREAM, AS AN ANTIOXIDANT, STRENGTHENER, PARTIAL DISINFECTANT, TASTE INTENSIFIER
CANNING
MISCELLANEOUS FOODS, AS A SUBSTITUTE FOR VACUUM PACKING
COCONUT COFFEE, TOBACCO, NUTS
PERMITS USE OF LIGHTER CONTAINERS
ANTIOXIDANT, FLAVOR CONSERVER, FLAVOR INTENSIFIER, ANTI-CORROSIVE, DISINFECTANT
BEVERAGES
WINE PROTECTION FROM MOLDS
AS AN INERT GAS FOR ELIMINATING SULFUR DIOXIDE FROM BLEACHED GOODS
AS AN ANTIOXIDANT IN PROTECTING FLAVOR, VITAMINS, ETC. IN FRUIT JUICES AND EXTRACTS
CARBONATED BEVERAGES
FRUIT DRINKS
GINGER ALE
SODA WATER
BEER
CARBONATED MILK
MISCELLANEOUS DRINKS
ANTISEPTIC
PARTIAL DISINFECTANT
TASTE INTENSIFIER
ANTIOXIDANT
GIVES SPARKLING DRINK
MECHANICAL USES
SPRAY PAINTING
CLEANING PLUMBING
OPERATING RAILWAY SIGNALS
MOTIVE POWER FOR TORPEDOES
TESTING FOR LEAKAGE
INFLATING AUTOMOBILE TIRES
LOW-TEMPERATURE USES
1 MECHANICAL REFRIGERATION 1 APPARATUS COMPACT 2 NON FLAMMABLE 3 NO LEAKAGE NUISANCE 4 NON CORROSIVE
ESCHAROTIC AND REFRIGERANT IN MEDICINE AND SURGERY
FREEZING SAMPLES FOR ANALYSIS OF RUBBER, ETC.
LECTURE DEMONSTRATIONS OF LOW TEMPERATURE PHENOMENA
STARTING LIQUID-AIR MACHINES
FREEZING MIXTURES FOR GENERAL LABORATORY UTILITY
CHEMICAL INDUSTRIES
MANUFACTURE OF SALICYLIC ACID AND ASPIRIN
MANUFACTURE WET-PROCESS WHITE LEAD
PRECIPITATION OF ALUMINUM HYDROXIDE
SYNTHESIS OF UREA
MANUFACTURE OF PURE CARBONATES
LEBLANC, CLAUS-CHANCE, AND SOLVAY PROCESSES
BOILING OUT COTTON, WOOL, ETC.
VEHICLE IN GAS DISTILLATION OF TAR, PHTHALIC ANHYDRIDE, ETC.
PRECIPITATION OF CALCIUM IN SUGAR INDUSTRY
RECOVERY OF FLAMMABLE SOLVENTS
AS A DILUENT, E.G. MFR. CARBON BLACK & ETHYLENE OXIDE
NEUTRALIZING EXCESS ALKALI
ANTIOXIDANT IN CHEMICAL OPERATIONS
DISTILLATION, E.G. PHOSPHORUS COMPOUNDS
DIGESTION OF OXIDIZABLE SUBSTANCES
EXTRACTION, E.G. LOGWOOD
MEDICAL USES
ESCHAROTIC
INSECTICIDE
CARBONATED BATHS, AS A GENERAL STIMULANT
INSPIRATORY STIMULANT AFTER ASPHYXIA AND ANESTHESIA
HUMANE KILLING OF ANIMALS
LOCAL REFRIGERANT ANESTHETIC
STORED MATERIALS
GRAIN
MILK
FIRE PREVENTION AND EXTINCTION
DUAL FIRES, MINES, STORAGE FILES
MISCELLANEOUS PLANT AND LABORATORY FIRES
SHIP FIRES
OIL TANKERS
MISCELLANEOUS CARGO
CARGO INCOMPATIBLE WITH WATER
ELECTRICAL FIRES, GENERATORS, TRANSFORMERS, H.T. FUSES, ELEC. OVENS, TELEPHONE SWITCHBOARDS
FIRES IN IMPREGNATING AUTOCLAVES FOR ELECTRICAL EQUIPMENT
MISCELLANEOUS USES
RUBBER INDUSTRY
INFLATING AIR-BAGS
CELLULAR PRODUCTS
ATMOSPHERE IN DRY-HEAT CURING
LOOSENING CERTAIN TYPES OF BOILER SCALE
WATER TREATMENT
RE-SOLUTION OF RESIDUAL CARBONATES
AS A PLANT FOOD IN GREENHOUSES AND TRUCK GARDENS

gas above it. This not only makes it possible to lower the temperature of the freezing mixture but it even makes it possible to fix the temperature by controlling the pressure with a vacuum pump and a gage. For instance, if the pump lowers the pressure of gaseous carbon dioxide over the solid to 65.7 mm., the temperature when equilibrium is reached will be —80°, if the pressure is lowered to 2.7 mm. the corresponding temperature will be —114°, while a pressure of 0.1 mm. corresponds to a temperature of —134°.[6]

Other Uses for Carbon Dioxide

It is impossible to discuss all of the uses of carbon dioxide in a paper of this type. Many chemical processes use this gas in varying concentrations. The Solvay Process, for instance, uses huge quantities of this compound in the manufacture of sodium carbonate and the beet sugar industry uses much low-grade gas made from lime rock. Perhaps these uses can best be shown by means of the chart prepared by Jones[7] which indicates most of the uses of this gas. The heavy lines indicate the uses of the liquefied compound and the light lines indicate many applications for which the highly purified gas is not required. While some of these applications have never been able to attain a commercial standing, as in the case of making butter and ice cream in an atmosphere of carbon dioxide, yet it is important to know that they have been suggested and have received some attention.

[6] Zeleny and Smith, *Phys. Rev.*, **24,** 22 (1907).

[7] Jones, *Chem. and Met. Eng.*, **29,** 103–5 (1923).

Would Add Medical Examination to Graduation Requirements. Medical examinations with credits that count toward graduation should be added to school requirements, Dr. Francis E. Harrington, Minneapolis Commissioner of Health and Director of Hygiene, recently told members of the American Public Health Association meeting at Minneapolis.

Health education and physical development are so important that they should be given the same weight as any other subject in the curriculum, in Dr. Harrington's opinion. Children should be required to pass a medical examination as well as other examinations in order to graduate. Dr. Harrington demonstrated a card on which to record such an examination, and pointed out that standards to base the examination on must be set up.

Because the American people are fast becoming health conscious, opportunities for school health workers will be much better, prophesied Dr. Svon Lokrants, medical director of the Los Angeles city schools. Not only will they have a chance to do better work, but their salaries will be better, for people will realize that only the best in the profession should be employed and that these should be adequately paid. The training and qualifications of school physicians, school nurses, corrective teachers, physical education teachers, nutrition teachers, and technicians was then formulated by Dr. Lokrants.—*Science Service*

CHEMISTRY FOR THE AMATEUR PHOTOGRAPHER. III. THE CHEMISTRY OF DEVELOPMENT*

When a light-sensitive material is exposed for a short time to light, although the change which takes place may be so minute that it cannot be detected by any ordinary means, if the exposed material is placed in a chemical solution, which is termed the "developer," the chlorine or bromine is taken away from the silver, and the black metallic silver which remains behind forms the image. This image is, of course, made up of grains, because the original emulsion contains the silver bromide in the form of microscopic crystals, and when the bromide is taken away from each of these, the crystal breaks up and a tiny coke-like mass of metallic silver remains behind in exactly the same position as the bromide crystal from which it was formed, so that, whereas the original emulsion consisted of microscopic crystalline grains of the sensitive silver salt, the final image consists of equally microscopic grains of black metallic silver. This removal of the bromide from the metallic silver is known chemically as *reduction*. (It must be remembered that chemical reduction has nothing to do with the photographic operation known as the reducing of a negative; that is, the weakening of an over-dense negative where the word simply refers to the removal of the silver and is not used in the chemical sense.)

Chemical reducers are substances which have an affinity for oxygen and which can liberate the metals from their salts, such as the charcoal which is used to reduce iron from its ore. A developing solution is therefore one which contains a chemical reducer. All substances which are easily oxidized are, however, not developers, since in order that a reducer may be used as the photographic developer, it is necessary that it should be able to reduce exposed silver bromide but should not affect unexposed silver bromide, so that its reducing power must be within certain narrow bounds; it must be a sufficiently strong reducer to reduce the exposed silver salt, and at the same time must not affect that which has not been exposed. For practical purposes the developing agents are limited to a very few substances, almost all of which are chemically derived from benzene.

Developers

The commonest developing agents are pyrogallol (pyro), hydroquinone, monomethyl *para*-aminophenol sulfate (Elon), *para*-aminophenol, or *para*-aminophenol oxalate (Kodelon), and diaminophenol hydrochloride (Acrol).

Pyrogallol (or pyrogallic acid) is made from gallic acid, which is obtained from gall nuts imported from China. The gall nuts are fermented to obtain gallic acid, and the gallic acid is then heated in a still from which the pyrogallol is distilled over. Hydroquinone is made from benzene which is

* This series of articles is based upon selected chapters from "Elementary Photographic Chemistry" and "The Fundamentals of Photography," by Dr. C. E. K. Mees, published by the Eastman Kodak Company, Rochester, New York.

first converted into aniline and then oxidized. Although it is somewhat less powerful as a reducing agent than pyro, it has less propensity to give stain. It is a constituent of a majority of the better known commercial developers in use today. It keeps very well when used in tank developers because it does not oxidize as readily as pyro and is generally used in motion picture work.

Some time after pyrogallic acid and hydroquinone were in general use by photographers, there were introduced a number of new developing agents made from coal tar, which are very useful as supplements to the older developers. Several of these are based on a substance called *para*-aminophenol, which is made in the manufacture of dyes. When *para*-aminophenol is treated with methyl alcohol, the methyl part of the alcohol attaches itself to it and forms a compound called methyl-*para*-aminophenol, which is a more active developing agent than the *para*-aminophenol itself. Another developing agent of the same type is diaminophenol, which is prepared in a way similar to *para*-aminophenol.

Para-aminophenol, methyl-*para*-aminophenol and diaminophenol are all bases and the developing agents are their salts, the oxalate of *para*-aminophenol, the hydrochloride of diaminophenol, and the sulfate of methyl-*para*-aminophenol, being used.

Different reducing agents behave differently as developers. We cannot use Elon in the place of hydroquinone and get the same effect. An image developed with Elon comes up very quickly and gains density slowly, while the hydroquinone image comes up very slowly but gains density steadily and rapidly. A very little change in the temperature affects hydroquinone greatly and affects Elon very little, and in the same way a small quantity of sodium or potassium bromide affects hydroquinone and does not affect Elon nearly so much. These differences in the developing agents depend upon the chemical nature of the substances themselves, and the particular property to which these differences are due is called the "reduction potential" of the developer.

The reduction potential alone does not determine the speed with which the developer develops the image, because this depends chiefly upon the rate at which the developer diffuses into the film and on the quantity of developing agent and other substances in the developer. A high reduction potential enables a developer to continue to develop more nearly at a normal rate under adverse circumstances, such as at a low temperature or in the presence of bromide. The reduction potential of a developer, in fact, may be compared to the horse-power of an automobile which for other reasons than the power of its engine is limited in speed. If we have two automobiles and they are confined to a maximum speed of twenty miles an hour, then on level roads the one with the more powerful engine may be no faster than that with a weaker engine but in a high wind or on a more hilly

road the more powerful engine will allow the automobile to keep its speed while the machine with the weaker engine will be forced to go more slowly. We could indeed, measure the horsepower of an automobile by the maximum grade which it could climb at a uniform speed of 20 miles an hour.

In development, the analogy to the hill is the addition of bromide to the developer, since the addition of bromide greatly retards development, and it is found that the higher the reduction potential of a developer, the more bromide is required to produce a given effect. If we measure the developing agents in this way, we shall find that hydroquinone has the lowest reduction potential, then pyro, then Kodelon, and finally Elon, which has the highest. Hydroquinone has so low a potential that it is rarely used alone but is generally used with Elon. Kodelon can be substituted for Elon but more Kodelon has to be used in order to produce a developer of the same strength. Developers with a high reduction potential such as Elon, and to a less extent Kodelon, make the image flash up all over at once, because they start development very quickly even in the lesser exposed portions of the emulsion, while developers of low reduction potential, like pyro and especially hydroquinone, bring up the highlights of the image first and the shadows do not fully appear until the highlights are somewhat developed.

Alkalies

Most developing agents cannot develop at all when used by themselves. With the exception of Acrol, developing agents, in order to do their work, must be in an alkaline solution, and the energy depends upon the amount of alkali present. The developers of higher reduction potentia , which bring up the image very quickly, require less alkali than those of lower reduction potential. For instance, hydroquinone is often used with caustic alkalies, while the other developing agents require only the weaker carbonated alkali.

The quantity of alkali governs the energy of a developer, and if too much alkali is present, the developer will tend to produce chemical fog while if too little alkali is present, it will be slow in its action. Alkalies also soften the gelatin of the emulsion, and consequently too alkaline a developer will produce over-swelling and will give trouble with frilling or blisters in warm weather.

The alkalies generally used for photographic work are not the caustic alkalies but the carbonates, which are salts of carbonic acid, H_2CO_3. Carbonic acid is a very weak acid, so that in solution the carbonates are not neutral but alkaline because of the predominance of the strong base over the weak acid, the carbonate being, to some extent, split up into the bicarbonate or acid carbonate and the caustic alkali. The use of a carbonate in development, therefore, represents a sort of reservoir of alkali, only a small

quantity of alkali being present at any time, but more being generated by dissociation of the carbonate as it is used up. If instead of using carbonate we were to use for development a solution containing a proportional quantity of caustic alkali, we should have only a small quantity of alkali present, and it would soon be exhausted. The used carbonate, therefore, enables us to employ a small concentration of alkali and yet to keep that concentration nearly constant during use.

When a salt is dissolved in water at a high temperature until no more will dissolve and then the solution is allowed to cool, the salt will generally be deposited in crystals; sometimes, as in the case of silver nitrate, the crystals consist of the pure substance, but more often each part of the salt combines with one or more parts of water to form the crystals. This combined water is called "water of crystallization." Thus, crystals of sodium carbonate formed from a cool solution contain ten molecules of water to one of carbonate, and their composition should be written $Na_2CO_3 \cdot 10H_2O$. A molecule of sodium carbonate, Na_2CO_3, will weigh 106 units, while a molecule of water, H_2O, weighs 18 units, so that the crystals of sodium carbonate contain 106 parts by weight of sodium carbonate and 180 by weight of water, and consequently crystallized sodium carbonate contains only 37% of dry sodium carbonate. If sodium carbonate is crystallized from a hot solution, only one molecule of water is combined in the crystals with each molecule of sodium carbonate so that they have the composition $Na_2CO_3 \cdot H_2O$ and contain 85% of dry carbonate. Sodium carbonate containing ten molecules of water of crystallization loses nine of them by drying in the air and breaks up, forming the compound with one molecule of water. This last molecule of water is only removed with difficulty by heating in the air, when the dry carbonate is formed, containing only a small residual quantity of water and about 98% carbonate.

When exposed to the air chemicals often either absorb or give up water. Those which absorb water are said to be "hygroscopic," and if they absorb so much that they dissolve and form a solution they are said to be "deliquescent." Chemicals which give up water to the air, so that the crystals break down and become covered with powder, are called "efflorescent."

Sodium carbonate comes on the market in three forms: Crystals with ten molecules of water, $Na_2CO_3 \cdot 10H_2O$ containing 37% of the carbonate; crystals with one molecule of water, $Na_2CO_3 \cdot H_2O$ containing 85% of the carbonate, and the dry powder containing 98% of the carbonate. The carbonate is made by treatment of salt solution with ammonia and carbon dioxide which reacts with the salt to produce sodium bicarbonate, $NaHCO_3$. The bicarbonate is heated and half of the carbonic acid driven off, producing crude sodium carbonate, which at this stage is known as "soda ash." This is then dissolved in water, and crystals of "sal soda," containing ten molecules of water, are produced. From this a crystalline salt with either

one or ten molecules of water is prepared for photographic use, but owing to the uncertainty of the composition of these crystals it is better to prepare the pure dry carbonate. This is obtained by heating the pure bicarbonate which can be precipitated from a solution of sal soda by means of carbon dioxide gas. When the bicarbonate is heated in the air, half of the carbonic acid is driven off, and sodium carbonate, Na_2CO_3, is produced according to the equation:

$$2NaHCO_3 = Na_2CO_3 + CO_2 + H_2O$$

The exact amount of heating is very important. If it is not done for sufficient time there will be a large quantity of bicarbonate left in the product, and bicarbonate is practically useless as an alkali in photography. On the other hand, if heating is continued too long, caustic soda will be produced. In the preparation of photographic carbonate the heating should be continued so that the material is almost pure sodium carbonate containing practically no bicarbonate. Much caustic soda would be fatal, but it is better to have a trace of caustic soda than bicarbonate.

Potassium carbonate is sometimes used instead of sodium carbonate in developer formulas. Although it is more soluble than sodium carbonate, it has the disadvantages of being more expensive and of absorbing water very readily. It must, therefore, be kept in well-sealed bottles.

Another alkali which has come into extensive use recently is borax. This chemical is recommended for use in a developer especially suited for the production of fine-grained motion picture negatives. Every photographic image is composed of tiny coke-like masses of silver bromide in the sensitive emulsion. The advantage of keeping the particles as small as possible is obvious, especially in motion picture work where the individual pictures comprising a film are enlarged several hundred times during projection. One of the causes of "graininess" or the coarsening of these tiny particles in the picture image is the fusion or clumping of the grains which occurs during development. Experiments have shown that several silver halide crystals in close proximity to each other, even though unexposed, may become developed and form a clump as a result of actual contact with an exposed crystal.

Borax or sodium tetraborate is prepared from certain calcium ores by first roasting, then boiling in sodium carbonate and bicarbonate solution, and finally crystallizing in large iron vats. A new source of borax discovered in Kern County, California in 1926 is virtually pure sodium borate and requires only dissolving, filtering, and recrystallizing to prepare it for the market. The pure salt forms large crystals readily soluble in hot water. It is used in developers for the production of fine-grained negatives and in acid hardeners for prints which are to be dried on belt driers.

Preservatives

Owing to the fact that developers are necessarily substances which have a great affinity for oxygen and that the air contains oxygen, developing solutions containing only developing agent and alkali would be rapidly spoiled from oxidation by the air. In order to make the developer keep there is added to the developing solution, in addition to the reducing agent and alkali, some sodium sulfite. Sodium sulfite has a very strong affinity for oxygen, being easily oxidized to sodium sulfate so that it protects the developer from the oxygen of the air, thus acting as a "preservative." This action of the sulfite is very easily seen with the pyrogallol developer. The oxidation product of pyrogallol is yellow, and this oxidation product which is formed in development is deposited in the film along with the silver so that if we use a pyrogallol developer without sulfite we shall get a very yellow negative, the image consisting partly of silver and partly of the oxidized pyrogallol. If we use sulfite in the developer, the image will be much less yellow because the pyrogallol will be prevented from oxidizing, the sulfite being oxidized instead, and finally if we add a great deal of sulfite, we shall get almost as blue an image as with Elon, the oxidation product of which is not deposited in a colored form with the silver.

Sodium sulfite is prepared by blowing sulfur dioxide gas into a solution of sodium carbonate. When sulfite is crystallized from the cooled solution it forms crystals containing seven molecules of water to one of sulfite of the composition $Na_2SO_3 \cdot 7H_2O$, which contain, when pure, 50% of dry sulfite. These crystals give up water when kept in the air and form a white powder on the surface. Since sulfite, when exposed to the air, has a tendency to oxidize to the sulfate, and as the sulfate is not a preservative, it is well to view with suspicion sulfite which has effloresced to a great extent. A quick rinse in cold water will remove the white powder from the crystals.

Sulfite free from water is produced by two methods: by drying the crystals, which produces what is called the "desiccated" salt, containing about 92% of pure sulfite, and by precipitation from hot solutions which gives a compound generally called "anhydrous" sulfite, and which contains as much as 96.5% of sulfite.

Sodium forms a number of compounds with sulfurous acid in addition to sodium sulfite itself. Thus there is sodium acid sulfite or bisulfite, $NaHSO_3$, which may be regarded as a compound of sodium sulfite with sulfurous acid:

$$\underset{\text{Sodium sulfite}}{Na_2SO_3} + \underset{\text{Sulfurous acid}}{H_2SO_3} = \underset{\text{Sodium bisulfite}}{2NaHSO_3}$$

Another, sodium metabisulfite, is a compound of sodium sulfite with sulfur dioxide:

$$\underset{\text{Sodium sulfite}}{Na_2SO_3} + \underset{\text{Sulfur dioxide}}{SO_2} = \underset{\text{Sodium metabisulfite}}{Na_2S_2O_5}$$

Since sodium bisulfite may be considered as a compound of sodium sulfite and sulfurous acid, while sodium sulfite is alkaline, bisulfite is preferable as a preservative in the case of a two-solution developer, since oxidation progresses less readily in acid than in alkaline solution.

In the case of a one-solution developer containing, say, sodium sulfite, sodium bisulfite and sodium carbonate, the bisulfite is converted to sulfite by the sodium carbonate according to the following equation:

$$NaHSO_3 + Na_2CO_3 = Na_2SO_3 + NaHCO_3$$

The sodium bisulfite neutralizes or destroys an equivalent quantity of sodium carbonate, thus reducing the proportion of alkali and therefore exerts an apparent restraining action, while the developer apparently keeps longer because some of the carbonate has been destroyed.

It might be thought from the above equation that it would be as effective and perhaps simpler to use only sodium sulfite instead of sulfite and bisulfite, but experiments have shown that the bicarbonate formed acts as an anti-fogging agent.

How to Mix Developing Solutions

A developer usually contains four ingredients as follows:

1. *The developing agent* (Elon, hydroquinone, pyro, *para*-aminophenol, etc.).
2. *The alkali* (carbonates and hydroxides of sodium, potassium, lithium and ammonium).
3. *The preservative* (sulfites, bisulfites, and meta-bisulfites of sodium and potassium).
4. *The restrainer* (bromides and iodides of sodium and potassium).

If a developing agent like hydroquinone is dissolved in water, the solution will either not develop at all or only very slowly, and on standing it will gradually turn brown, because of what is called oxidation or chemical combination of the hydroquinone with the oxygen present in the air in contact with the surface of the liquid. This oxidation product is of the nature of a dye and will stain fabrics or gelatin just like a dye solution.

On adding a solution of an alkali such as sodium carbonate, the hydroquinone at once becomes a developer, but at the same time the rate of oxidation is increased to such an extent that the solution very rapidly turns dark brown, and if a plate is developed in this solution it becomes stained and fogged.

If we add a little sodium bisulfite to the brown-colored solution mentioned above, the brown color or stain is bleached out and a colorless solution is obtained. Therefore, if the preservative is first added to the developer, on adding the accelerator the solution remains perfectly clear because the sulfite preserves or protects the developing agent from oxidation by the air.

As a general rule, therefore, the preservative should be dissolved first.

An exception to this rule should be observed with concentrated formulas containing the developing agent, Elon. This substance is readily soluble in warm water [about 125°F. (52°C.)] and does not oxidize rapidly. If the sulfite is dissolved before the Elon, as is the case with developers such as hydroquinone, a white precipitate often appears, especially if the sulfite solution is concentrated. This precipitate forms because Elon is a combination of an insoluble base with an acid which renders it soluble. When the acid portion is neutralized by a weak alkali such as sodium sulfite, the insoluble base is precipitated. This Elon precipitate is soluble in an excess of water and also in a sodium carbonate solution with which the base forms a soluble sodium salt. When once the Elon is dissolved, however, it takes a fairly high concentration of sulfate to bring it out of solution again, though only a low concentration of sulfite is required to prevent the Elon from dissolving. If a precipitate forms on dissolving the Elon and sulfite, this will usually redissolve on adding the carbonate and no harm has been done.

Some direction sheets recommend that a portion of the sulfite should be dissolved in order to prevent the oxidation of the Elon, then dissolve the Elon, and then the remainder of the sulfite. Many workers add a little of the solid sulfite to the Elon when dissolving the latter. This procedure is quite satisfactory, though if the Elon is dissolved alone in water at a temperature not above 125°F. (52°C.), and the sulfite dissolved immediately afterward, little or no oxidation products will be formed which would otherwise produce chemical stain.

The alkali (usually carbonate) may be added in one of three ways:

(*a*) Dissolve the carbonate separately and add to the cooled Elon-sulfite solution. There is danger, however, of the Elon precipitating before the carbonate is added.

(*b*) Add the solid carbonate to the Elon-sulfite solution, stirring thoroughly until dissolved.

(*c*) After dissolving the Elon, dissolve the sulfite and carbonate together, cool and add to the Elon-solution.

Bromides and iodides are added to a developer to compensate for any chemical fog produced by the developer, or inherent in the emulsion. It is immaterial at what stage the bromide is added during the mixing.

When mixing a developer the following rules should, therefore, be followed:

1. Dissolve the chemicals in the order given unless the mixing directions specify changes in the order of solution. If a formula contains both sulfite and bisulfite, it is usual to dissolve these together, that is the bisulfite is dissolved in the same order as the sulfite.

2. Dissolve each chemical completely before adding the next. If the

alkali is added before the crystals of the developing agent are dissolved, each crystal becomes oxidized at the surface and the resulting solution will give fog.

3. Mix the developer at the temperature recommended, which is usually not above 125°F. (52°C.).

4. In the case of desiccated chemicals like sodium carbonate and sodium sulfite, add the chemical to the water and not vice versa.

Two practical methods of mixing are possible, as follows:

(*a*) Dissolve all the chemicals in one bottle or vessel by adding the solid chemicals to the water in the correct order (in the formula the ingredients should be named in the order in which they are dissolved). For example, to mix the following formula:

	Avoirdupois	Metric
Elon	45 grains	3.1 grams
Sodium sulfite	1½ ozs.	45.0 grams
Hydroquinone	135 grains	9.5 grams
Sodium carbonate	2½ ozs.	75.0 grams
Potassium bromide	15 grains	1.1 grams
Water to make	32 ozs.	1.0 liter

proceed as follows:

Dissolve the Elon in 16 ozs. (500 cc.) of water (about 125°F.) (52°C.), then add the sulfite, and when completely dissolved, add the hydroquinone. Finally add the carbonate and bromide and cold water to make 32 ozs. (1 liter).

For large quantities the filter bag method should be used, the chemicals being placed in the bag and dissolved in the above order.

(*b*) An alternative method is to dissolve the preservative and developing agent in one vessel and the carbonate and bromide in another, cool and mix. This method is the safest and best for quantity production.

For example, to mix the following motion-picture developer,

	Avoirdupois	Metric
Sodium sulfite	4 lbs.	1800.0 grams
Hydroquinone	13 ozs.	390.0 grams
Sodium carbonate	4 lbs.	1800.0 grams
Potassium bromide	3 ozs.	90.0 grams
Water to make	10 gals.	40.0 liters

proceed as follows:

Dissolve the sulfite in about one gallon (4 liters) of water (125°F.) (52° C.), then dissolve the hydroquinone and filter into the tank. Then add one gallon (4 liters) of cold water to the tank, dissolve the sodium carbonate and bromide in one gallon (4 liters) of hot water and filter this into the tank, immediately adding cold water up to ten gallons (40 liters). The

object of adding cold water to the tank before adding the carbonate is to cool off the solution before the carbonate is added.

Mixing Concentrated Developers

The extent to which a developer may be concentrated is determined by the solubility of the least soluble constituent, because a stock solution should usually withstand cooling to 40°F. (4.4°C.) without any of the ingredients crystallizing out. Usually, the hydroquinone and Elon come out of solution on cooling, but this may be prevented by adding wood alcohol or methanol in a concentration up to 10%. Denatured alcohol may be used if wood alcohol has been added as the denaturant. If a precipitate forms, however, on adding the denatured alcohol to the developer, the denatured alcohol is unfit for use.

The addition of the alcohol does not prevent the other ingredients such as sodium sulfite from crystallizing out; in fact, the alcohol diminishes their solubility and therefore increases the tendency to come out of solution.

A *para*-aminophenol-carbonate developer is difficult to prepare in concentrated form, though by adding a little caustic soda the solubility of the *para*-aminophenol is increased and a stronger solution can be thus prepared.

When preparing concentrated developers it is important to observe carefully the rules of mixing, taking care to keep the temperature of the solution as low as possible if a colorless developer is to be obtained.

The following formula is a typical example of a concentrated developer and is prepared by dissolving the ingredients in the order given:

	Avoirdupois	Metric
Water (about 125°F.) (52°C.)	16 ozs.	500.00 cc.
Elon	75 grains	5.3 grams
Sodium sulfite	2 1/2 ozs.	75.0 grams
Hydroquinone	3/4 oz.	22.5 grams
Sodium carbonate	3 1/2 ozs.	105.0 grams
Potassium bromide	38 grains	2.7 grams
Wood alcohol	4 1/2 ozs.	136.0 cc.
Cold water to make	32 ozs.	1.0 liter

Two-Solution Developers

A two-solution developer is simply a one-solution developer split into two parts, one containing the carbonate and bromide, the other containing the developing agent and preservative so that the developer will oxidize less readily and therefore keep well. The reason why it is customary to keep a developer like pyro in two solutions, is because pyro oxidizes much more readily than Elon or *para*-aminophenol with a given amount of preservative.

For purposes of mixing only one-solution developers need be considered because the same rules regarding mixing apply in both cases.

Using Solutions

Photographic solutions, especially developers, vary considerably in their period of usefulness or time during which they may be utilized effectively to process exposed films and papers. This "useful life," as it is sometimes called, is therefore an important property of a solution and should be studied by every one handling photographic materials. There are a good many factors which influence the useful life of a solution, such as whether it receives intermittent or continuous use, the extent of the surface exposed to the air, the temperature, the nature and reactions of the chemical constituents, and the manipulative procedure used in handling films or prints in the bath.

The Useful Life of Developers

Without Use.—If a freshly mixed developer (prepared with water boiled to free it from dissolved air) is stored in a completely filled and stoppered or wax-corked bottle, it will keep almost indefinitely even in the light. Under ordinary conditions of storage, the bottle or vessel contains more or less air. Also, when an ordinary cork or a non-airtight cover is used, the surface of the developer is continually in contact with air, the oxygen constituent of which oxidizes the developing agent and sodium sulfite present. This results in a lowering of the developing power in direct proportion to the amount of oxidation of the developing agent, which is accelerated as the preservative or sodium sulfite becomes oxidized also.

The oxidation products of developing agents are usually colored so that the developer on keeping frequently turns brown. In the presence of sodium sulfite, however, the oxidation products of hydroquinone consist of mono- and disodium sulfonates which are colorless. The fact that an old Elon-hydroquinone developer is colorless is, therefore, no indication that the original developing power is unimpaired. An oxidized Elon or Elon-hydroquinone developer also frequently fluoresces strongly.

In some cases when an Elon-hydroquinone developer gives slight developer fog when freshly mixed, the fogging tendency disappears on standing. This may be due to the anti-aerial fogging action of the developer-oxidation products which are produced on keeping.

A solution of a developing agent, such as pyro, to be stored for a considerable time, will keep best in the presence of an acid sulfite such as sodium bisulfite rather than sodium sulfite which is slightly alkaline. It is always preferable, therefore, to prepare such a developer as two solutions: one containing the developing agent and sodium bisulfite; and the other the carbonate and bromide, and to mix these solutions as required for use. A plain solution of sodium sulfite oxidizes readily in contact with air at a concentration below 10%, but above this concentration it oxidizes very slowly. Stock solutions containing sodium sulfite alone or in combination

with a developing agent should be prepared, so that the concentration of the sulfite is around 10% for maximum keeping properties. Owing to the relative insolubility of Elon in a sodium sulfite solution, it is not possible to prepare such stock solutions with Elon.

Sodium bisulfite keeps satisfactorily in more dilute solutions and is a better preservative than sulfite in the absence of carbonate. It is usual, therefore, to keep readily oxidizable developing agents such as pyro, admidol, etc., by mixing with sodium bisulfite. On adding sodium bicarbonate to sodium bisulfite, sodium sulfite and sodium bicarbonate are formed, so that in compounding a two-solution formula from a one-solution formula it is necessary to take care of this neutralization of the carbonate by using an extra quantity.

Single solution developers containing sodium hydroxide or potassium hydroxide do not keep unless well stoppered, pure gum rubber stoppers being most suitable.

With Use.—During development, several reactions are taking place: (1) The developing agent and sulfite are being oxidized by the air; (2) the developing agent is being destroyed as a result of performing useful work in reducing the exposed silver halide emulsion to metallic silver; and (3) oxidation products of the developer and the by-products, sodium bromide and sodium iodide, are accumulating. The bromide and iodide and developer oxidation products restrain development while the oxidation products prevent aerial fog. The restraining action of the bromide and iodide is analogous to cutting down the exposure, so that with an old developer it is not possible even on prolonged development to get the ultimate result out of an under-exposure.

The time required to produce a definite contrast increases as a developer is used, and the solution ceases to be useful when the time required for this exceeds the maximum time which can be allotted for the developing operation. A deep tank developer, for example, is therefore discarded for one or more of the following reasons: (1) the time for complete development is excessively long; (2) the solution stains or fogs emulsions badly; and (3) the accumulation of by-products is so great that shadow detail is lost even with full development.

Developer Troubles

The Developer Gives Fog.—Fog is the chief trouble caused by faulty mixing. It may be a result of violation of the rules of mixing such as dissolving the carbonate before the sulfite, mixing the solution too hot, omitting the bromide, adding too much carbonate or too little sulfite, the use of impure chemicals, etc.

With certain developers, notably those containing Elon and hydroquinone, a form of fog, known as aerial fog, is produced when film wet with

developing solution is exposed to the air. Motion picture positive film developed on a reel is especially sensitive to aerial fog. It may be prevented by adding about 5% of old developer to the freshly mixed developer. This is more effective than increasing the concentration of bromide above the normal quantity added. The oxidized developer probably acts as an anti-fogging agent thus reducing the tendency for fog formation.

Negatives developed in a developer containing an excess of sulfite or one containing hypo or ammonia may show *dichroic* or *green fog*. This appears yellowish green by reflected light, and a pink color by transmitted light. It is usually caused when the dissolved silver salts, under certain conditions, are reduced to metallic silver in a very fine state of subdivision, particularly in the shadow portions of the negative where no bromide is liberated during development. Fine-grained emulsions are most susceptible to this form of fog.

Some deep tank developers may begin to fog a short time after they have been put into use. When this occurs it usually can be traced to the presence of sulfide in the solution caused by the action of bacteria which reduced the sulfite in the developer to sulfide. The fog may be cleared up by putting some waste film or plates through the solution or by adding a small quantity of lead acetate to the developer. The bacteria or fungi usually grow in the slimy deposit which accumulates on the inner walls of the tank. This deposit may be removed by sterilizing the container occasionally with bleaching powder.

The Solution is Colored.—As a general rule, the developer when mixed should be colorless and if colored it should be suspected as being likely to give fog. In the case of a pyro developer mixed with bisulfite, which contains iron, an inky substance is formed as a combination product of the iron and the pyro, and this imparts a dirty bluish red color to the solution, although photographically it is harmless. If a two-solution pyro developer is mixed in dirty vessels the B solution (which contains the carbonate and bromide) may be colored brown by the presence of a little pyro.

The Solution Does Not Develop.—Omission of the developing agent or the carbonate may usually be suspected if a developer does not develop.

Precipitation of a White Sludge.—If a white precipitate settles on standing, this is probably Elon. The precipitate may often be redissolved by adding 5% of wood alcohol or methanol, but if this is not successful, then the formula contains either too much Elon or sulfite or not enough carbonate. If it is known that the formula gives a clear solution when mixed correctly and should the Elon precipitate out during mixing when the sulfite is added, the precipitate will usually redissolve on adding the carbonate. If the final solution is not colored, no harm will have been done.

Scum.—Scum may be picked up on films or plates from the surface of

the developer especially if the solution has been allowed to stand unused for several days. The scum may consist of grease, solid matter, or developer oxidation products, especially if the developer contains pyro. The scum should be removed by passing the edge of a blotting paper along the surface of the solution or by using a skimmer, consisting of several layers of cheese cloth stretched over a square wire frame.

Miscellaneous Troubles.—Various types of developer stains may be produced on films, plates, and papers. When a developer solution is not agitated sufficiently during the progress of development, characteristic markings are produced. This is occasionally observed with film developed on hangers or racks. These markings are usually the result of retardation of development along the sides of a hangar or rack caused by the accumulation of oxidized developer products and sodium bromide. They may be prevented by thorough agitation of the holder or rack during development.

The Importance of Rinsing

It is important to rinse films, plates, and papers after development and before fixation. When a film or print is transferred from the developer directly to the fixing bath the alkali in the developer retained by the film or print neutralizes some of the acid of the fixing bath. The addition of developer also gradually destroys the hardening properties of the fixing bath. Therefore, by removing as much developer as possible from the film or print by thoroughly rinsing in water or an acid rinse bath for 10 or 20 seconds, the life of the fixing bath is very much prolonged, while the tendency for stains and blisters to form is very much reduced.

Study Methods of Testing Radioactivity of Water. With a market flooded with waters, salves, hair tonics, tissue creams, mouth washes, healing pads and other preparations alleged to have great healing power because of their radioactivity, government chemists are working on suitable means of detecting the presence or absence of radioactive substances in water and drugs.

At the recent meeting in Washington of the Association of Official Agricultural Chemists, J. W. Sale of the U. S. Department of Agriculture, reported on one method of testing radioactivity. He recommended further checking of the method by chemists, before official adoption by the association.

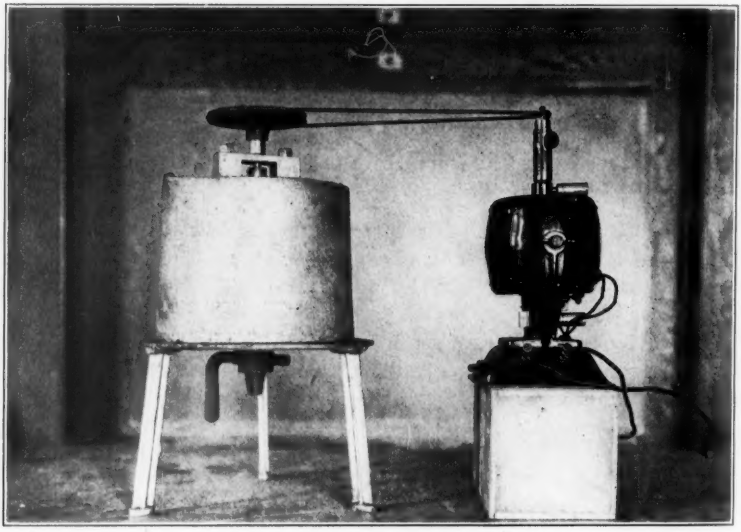
The discovery of the curative properties of radioactive substances has resulted, among other things, in the production of solid, semi-solid and liquid preparations which are being sold as possessing sufficient radioactivity to cure all kinds of conditions. A recent government survey of such waters and drugs revealed that their medicinal efficacy was much misrepresented. Action will be taken under the Federal Food and Drugs Act against shipments of the alleged radioactive products which are falsely or fraudulently misbranded under the terms of the law.

Radium and radioactive substances have possibilities of great harm as well as great good, it is declared. Using them indiscriminately without adequate supervision is extremely dangerous.—*Science Service*

WORKING MODEL OF A PLANT NITRATOR

S. C. Dennis, Girard College, Philadelphia, Pennsylvania

In October[1] the writer outlined briefly the system of instruction employed at Girard College, whereby advanced students or groups of students are allowed to work out projects dealing with commercial processes. In that article a miniature contact-process sulfuric acid plant, designed and built entirely by students, was described. The present note is a description of a working model of a plant nitrator constructed in connection with a similar project. Most of the dimensions and details of construction are



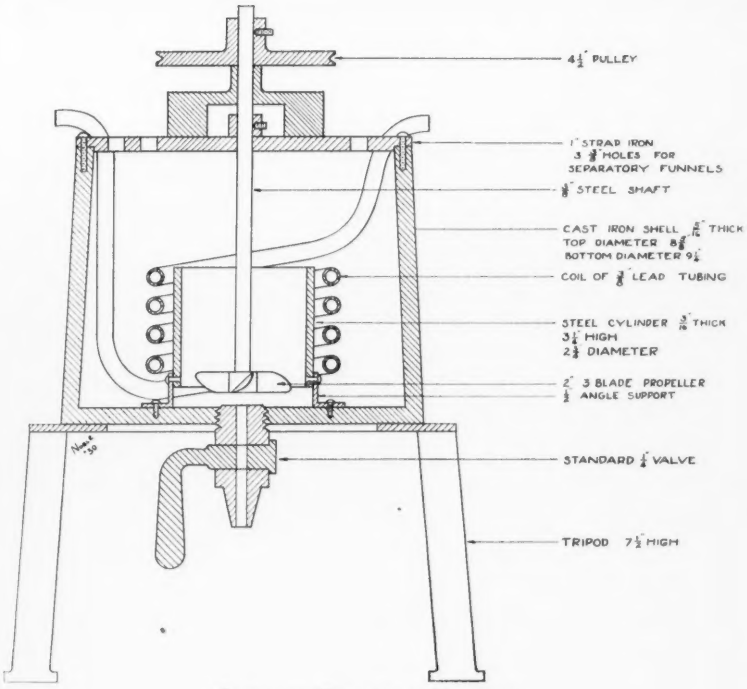
Working Model of Plant Nitrator

revealed by the accompanying diagram and photograph, but a few additional suggestions are offered for what they may be worth.

Materials and Construction

The shell of the nitrator is made of a good grade of cast iron, 7 inches deep and with a mean diameter of about 9 inches. It is supported by a heavy tripod $7\frac{1}{2}$ inches in height. For a sleeve we used a steel cylinder $2\frac{3}{4}$ inches in diameter and fastened it to the bottom of the nitrator by means of $\frac{1}{2}$-inch angle supports. A 2-inch propeller with three blades is placed flush with the bottom of the sleeve. Around the sleeve is wound a cooling coil of $\frac{3}{8}$-inch lead tubing.

[1] This Journal, **6**, 1781–3 (Oct., 1929).



SECTIONED DIAGRAM OF NITRATOR

A mixture of spent acids (nitric and sulfuric) is added to the nitrator until the propeller is capable of lifting the mixture over the sleeve. The calculated amount of the material to be nitrated (benzene) is now added and the contents cooled by pumping the mixture over the lead coil. When the mixture has been cooled to the desired temperature, add slowly from a large separatory funnel the correct amount of fuming sulfuric and nitric acids. The time required for adding the mixed acids will depend upon the speed of the propeller and temperature at the water in the cooling coil. When the nitration is complete, the contents are allowed to settle for several minutes. By using the valve on the bottom of the nitrator, it is possible to draw off, first, the heavy spent acids and finally the nitrated product. Products such as nitrobenzene should be washed several times with water and finally with a solution of sodium carbonate.

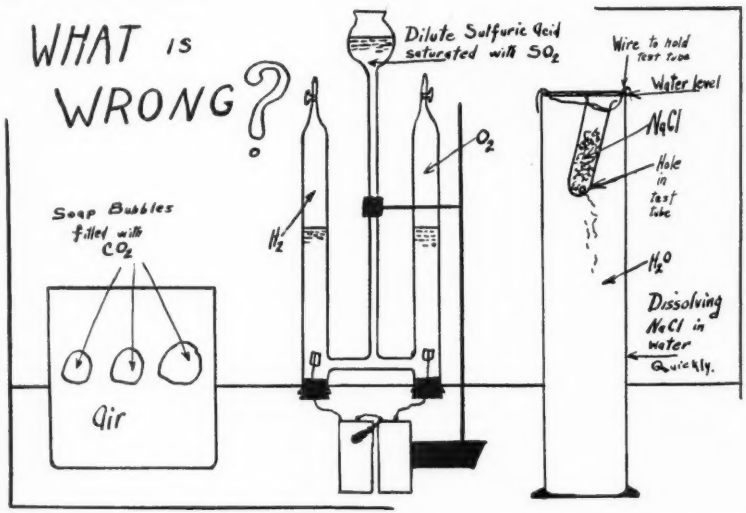
The yield, quality of the product, and concentration of the spent acids offer excellent opportunity for the student to make special investigations.

CONTEST FOR HIGH-SCHOOL AND FRESHMAN STUDENTS

On this page is reproduced the fifth of a series of drawings prepared for us by Prof. John J. Condon of William Nottingham High School, Syracuse, New York. Write a brief statement, telling what is wrong with the picture. Use complete sentences; do not merely list mistakes. Type your manuscript, if possible; if not, be sure that you write legibly. Type or write on one side of the paper only.

Make a correct drawing, showing the picture as you think it should be. Use black India ink and white drawing paper. (If you believe that you can draw better on coördinate paper, white paper with blue rulings must be used.) Drawings should be approximately 4″ × 6″ or 8″ × 12″.

Place your name at the top of each page of your manuscript and at the top of your drawing.



On a separate sheet accompanying your manuscript write your own name, the name and address of the institution at which you are a student, the name of your chemistry instructor, and the name of the chemistry club at your institution (if there is one).

Address your paper to: The Associate Editor, JOURNAL OF CHEMICAL EDUCATION, The Johns Hopkins University, Homewood, Baltimore, Md.

Your contribution to this month's contest must be postmarked not later than February 15th.

Awards

The best contribution received will be awarded a prize of five dollars. The five next best papers will receive awards of one dollar each.

Contributions will be judged on the basis of:

1. Correctness from a chemical standpoint
2. Neatness and correctness of drawing
3. English
4. Neatness and legibility of manuscript.

Papers which do not comply with all of the rules of the contest will not be considered.

New Test Predicts Success of Medical Students. A test which can be given to students who apply for entrance to medical schools, designed to sort out the students who will make good from the students who are likely to fail, was described recently by Prof. Fred A. Moss, of George Washington University, who spoke before a meeting at Columbia University of the American Association of Medical Schools.

Present methods of selecting medical students notedly result in much misplaced energy, and great waste of time and money. Prof. Moss, who is a physician as well as psychologist, pointed out that about 7100 students started on freshman courses toward a medical degree last year, and of these more than 1000 put in a year's study, only to flunk the freshman course. Medical school officials who picked the 7100 turned down about 20,000 applications. The usual grounds for selection were the number of pre-medical college credits held by an applicant and his ratings on his college studies.

A psychological test of aptitude for a medical course has been devised by Prof. Moss and two associates, Dr. Oscar B. Hunter and H. F. Hubbard, and an experiment which gages its efficiency has very recently been conducted, the psychologist explained. Twenty-two medical schools gave the test to their students at the close of the freshman year to see whether the test could have predicted the students' learning ability.

Among the students who were picked out by the test as the best of the lot, none failed in their courses. At the other end of the scale, among the students rated lowest by the test, 42 per cent failed the freshman course and 44 per cent were conditioned.

The experiment indicates that by refusing admission to prospective students who fail to pass the aptitude test, a medical school could eliminate 75 per cent of the applicants destined to fail. At the same time the test would eliminate only 12 per cent of the students who would have ranked among the best medical students. The method of selection now used by the schools appears to cut out about 60 per cent of the failures and 38 per cent of the best students.

Prof. Moss' aptitude quiz includes 100 questions on pre-medical subjects, a test of visual memory based on an anatomical drawing, a test of memory based on a passage from an anatomy textbook, and a test of ability to understand and recall a difficult neurological paragraph.—*Science Service*

Whatever your goal may be, strike out for it! What if you do fail? What if you die in the attempt? Well, if you put every shred of yourself into the attempt, you will have had life's one great exhilarating and soul-satisfying experience anyhow!

And when you start out to pursue your dreams, be prepared for a great discovery. It's the effort itself that will give you peace. This peace goes with you as you grow older, becomes your choicest companion, never leaves you. Wresting this peace from a troubled world is about all there is to the secret of happiness.—EMERSON

WINNERS IN THIRD "WHAT IS WRONG?" CONTEST

The third contest[1] was in some respects the most difficult to judge of any which have been held so far. This circumstance arose out of the fact that the object of the experiment was not expressly stated, nor was it clearly indicated by the drawing. Several interpretations, therefore, were possible to the contestants. One might disregard the object entirely, merely correcting errors in technic and stating the product which would be obtained by a process of distillation. One might assume that the object was to purify NH_4OH by distillation, or to derive ammonia from NH_4OH by heating, or to obtain *liquid* ammonia from NH_4OH. Some contestants assumed that the object was to prepare ammonia and suggested an entirely different process. Another chose to prepare pure water from NH_4OH solution and added sulfuric acid prior to distilling.

We believe that the first three methods of dealing with the problem are on the whole the most logical, and, with one exception, the winners have been chosen from among the contestants who adopted one of them. The exception receives an award because his paper constituted one of the best written criticisms of the original drawing and was accompanied by a diagram of fairly good appearance.

None of the contestants who elected to prepare *liquid* ammonia described or pictured an entirely practical apparatus, although several suggested cooling mixtures which should be capable of condensing ammonia at atmospheric pressures.

Several contestants suggested practical methods of drying ammonia gas, but one suggested the use of $CaCl_2$ which would not be suitable. [See THIS JOURNAL, **6**, 1777 (Oct., 1929)].

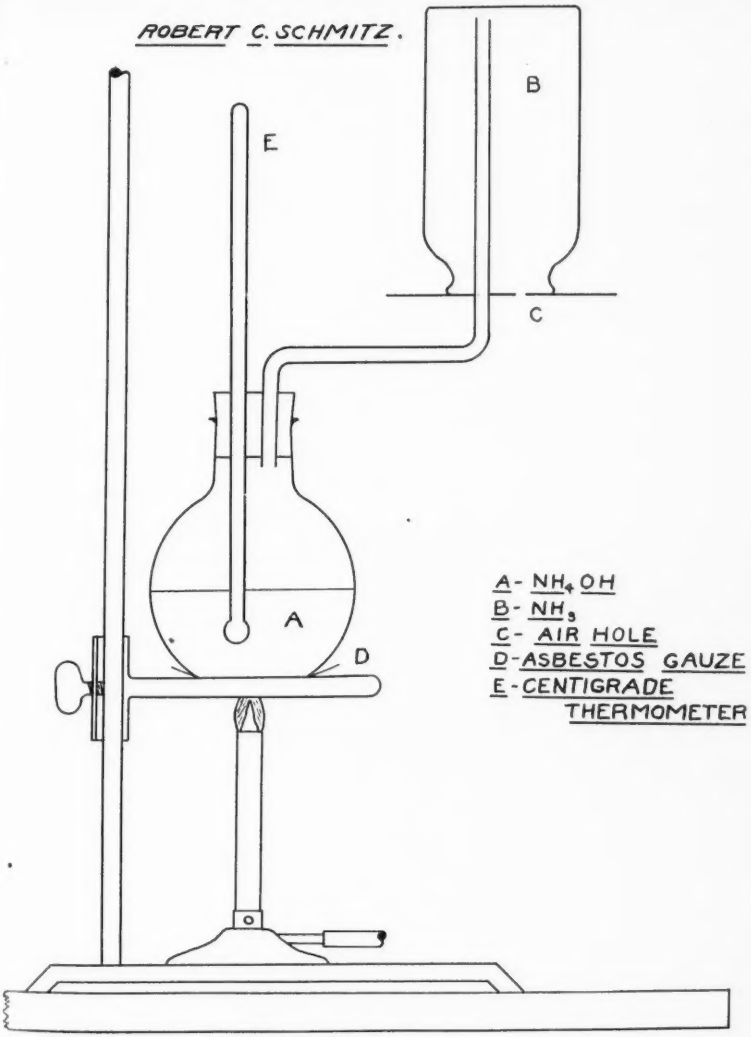
A number of contestants failed to note that the placing of the thermometer would differ, depending upon whether NH_4OH solution was to be distilled or NH_3 was to be driven off by heat.

As heretofore, greatest credit was given for observations relating to correct laboratory technic and to chemical facts. Criticisms of objects wrongly represented were also credited, provided that they touched upon points more fundamental than mere drafting technic. Greater weight was attached to statements accompanied by reasons than to bare assertions. The correctness and appearance of drawings played a large part in the final distribution of awards, since many contestants received nearly the same score on their written criticisms.

Robert C. Schmitz, of Milwaukee, Wisconsin, outpointed other competitors by a slight margin. His paper and drawing are reproduced herewith.

The drawing is imperfectly made, that is; the lines of the ring stands are not uniform. There are lines drawn through the gas hose and other passages in the drawing, and the ring stands are not drawn in proportion to the other apparatus.

[1] See THIS JOURNAL, **6**, 2262–3 (Dec., 1929).



There is no stopper in the flask containing ammonium hydroxide, therefore the ammonia gas will pass off into the atmosphere instead of being collected in a bottle.

The flask is not high enough above the Bunsen burner to receive the hottest part of the flame.

The Bunsen burner has no air holes, therefore a luminous flame will be the result. This kind of a flame is undesirable, because the flame is not as hot as the non-luminous

flame and due to the lack of oxygen the carbon is not completely oxidized and will consequently deposit on the flask.

In the drawing there is no asbestos gauze under the flask to prevent the flames from coming in direct contact with it, which may result in cracking the flask.

The thermometer, which, in the drawing is wrong side up, should be placed right side up in the solution and constantly observed, so that the temperature will not approach that of boiling water.

Ammonium hydroxide is an unstable basic solution and the slight application of heat will drive off the ammonia gas. This gas being lighter than air will rise and pass up into the collecting bottle. The delivery tube is extended high up in the collecting bottle to prevent the ammonia gas from mixing with a large amount of air. The gas will force the air out of the hole *C*, as shown in the accompanying drawing.

There is no stopper in the collecting bottle, thereby letting the ammonia gas escape into the atmosphere.

In the drawing the water is shown entering the condenser at the top, which is improper. To keep the condenser properly filled with water, the supply should be introduced at the lower opening and expelled from the upper.

The drawing shows the ammonia gas in a liquid state within the condenser and collecting bottle. It also shows the collecting bottle in ice water. It is impossible to have the ammonia in a liquid state under these conditions, for ammonia has a boiling point below zero. For this same reason the condenser and beaker of ice water are superfluous in this experiment.

Winners of the five one-dollar awards were: Hubert Rivers, Hutchinson, Kansas; Richard Kocher, Allentown, Penna.; Esther Elking, Dayton, Ohio; Virginia Mary Weber, Dayton, Ohio; Dwight Santiago, Aguadillo, Porto Rico.

American Rocket Experimenter Announces New Liquid Propellant. Development of a liquid propellant for rockets that will make possible airplanes much faster than those of the present day is announced in an article prepared for *Science Service* by Prof. R. H. Goddard, of Clark University, Worcester, Mass. Commenting on the recent experiments in Germany with a rocket propelled airplane, he said:

"The recent rocket plane flight in Germany raises the question as to just what bearing this result may have on aviation. According to German aeronautical journals, these rocket auto and airplane experiments are being carried out along the lines of the experimental work that I performed at Clark University in 1916 and which was published by the Smithsonian Institution in 1919.

"These published results described expansion nozzles of eight degree taper, electrical ignition by wires through these nozzles and the system of using bundles of similar rockets, all of which are now in use abroad.

"A plane equipped with powder rockets, however, has an extremely limited cruising radius unless it is used as a rocket glider. If, on the contrary, liquid propellants are used, capable of supplying a large amount of energy compared with an equal weight of powder and the amount of propellant carried is large compared with the weight of the rocket plane itself, some very surprising distances can be covered in a much shorter time than with an ordinary plane. The development work on liquid propellant rockets planned abroad is unnecessary as my work under the Smithsonian Institution has already produced liquid propellant rockets that operate."—*Science Service*

CALCIUM CHLORIDE FOR SNOW REMOVAL

LIONEL RICHARDSON, BROOKLYN, NEW YORK

Would you rather break your neck than get your feet wet?

It may be hard to tell. . . . Anyhow, this was the question that was put before the spectators who witnessed an extraordinary demonstration recently. Strange as it may seem, this demonstration was not carried on in a laboratory as one is likely to imagine.

This winter the Street Cleaning Department of the City of New York granted permission to a new concern, now in the process of formation

Wide World Photos

APPLYING CALCIUM CHLORIDE TO MELT SNOW IN NEW YORK STREETS

and to be called the Melt-Ice Company, to try out their experiment of melting the snow in the city streets by the use of calcium chloride ($CaCl_2$).

Accordingly, on the morning of December 5th, following a heavy snowfall, a truckload of the chemical was conveyed to a downtown section in Brooklyn where it was connected with a trailer. The trailer contains a sieve-like arrangement with holes spaced about two inches apart through which the granular calcium chloride passes and falls upon the trampled snow below.

The deliquescence of anhydrous calcium chloride in addition to its other specific chemical properties are made use of in this experiment. The anhydrous salt dissolves slowly in the damp snow with the liberation of

considerable heat. Furthermore, this chemical is a by-product in the manufacture of sodium carbonate by the Solvay process, as well as in the preparation of potassium chlorate from calcium chlorate. Hence, the supply is, at present, much greater than the demand.

So the new Melt-Ice Company, under the official scrutiny of the city Street Cleaning Department, has done a little slushy work, the outcome of which will be reported later. And that's precisely what the apparent result was to the observer after the calcium chloride had reacted with the snow exothermically. For the act of sprinkling the chemical on the snow does not produce an instantaneous reaction; but after observing the experiment for about twenty-four minutes even the skeptic will be convinced that something remarkable has happened. The report which the city authorities will make on this experiment should be interesting and important.

But impatient observers who viewed the proceedings on December 5th were disappointed to see such slow action and the ultimate (or should we say inevitable?) accumulation of slush after a considerable time. Perhaps they expected all the snow to disappear immediately upon the application of the calcium chloride. But science is not magic, although in many instances it may have seemed so. And so, it happened that one of the men who conducted the experiment that morning had occasion to ask a skeptic, "Would you rather break your neck than get your feet wet?"

But it's hard to tell.... meantime, every one is awaiting the report on this experiment.

Attempt to Increase Copper Content of Milk as a Substitute for Liver for Anemia Patients. Attempts to increase the nutritional value of milk by the simple technic of giving cows and goats more copper salts in their food than they would normally have access to, has failed to work.

The valuable factor in liver, which has become the up-to-date physician's most substantial prop in treating pernicious anemia, was recently found by Dr. E. B. Hart and a group of investigators at the University of Wisconsin to be copper rather than iron, as was first believed. Liver in the proportions necessary to produce curative effects, becomes an exceedingly disagreeable medicine to many patients. Other foods, consequently, that supply the needed element are highly desirable.

Naturally the Wisconsin investigators turned their thoughts to various ways of increasing the copper content in other foods. Milk, which in earlier analyses, showed from 0.38 to 1.4 milligrams of copper per liter, was found under carefully controlled conditions to have only 0.123 to 0.184 milligram per liter, not sufficient to prevent rats, fed on a milk diet, from developing anemia. The earlier figures are believed to be the result of contamination with copper from metal vessels used during analysis.

Cows and goats fed on an experimental diet showed milk with the same proportion of copper as that found in the recent analyses. Increasing the copper content of their food even in considerable proportions, however, did not produce any increase in the amount of the element in their milk. So anemia patients can't look to milk for relief from liver.—*Science Service*

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POPULAR SCIENCE MONTHLY, *January, 1930*

(*P. 20.*) "What Science Achieved in 1929." A series of very brief resumés by authorities in numerous fields of pure and applied science. Hugh S. Taylor, writing on chemistry, cites the development of hydrogenation processes for increasing the yield of gasoline from petroleum as the most important industrial achievement of the year. In pure chemistry he mentions the discovery of two distinct molecular forms of hydrogen and of isotopes of oxygen and carbon.

(*P. 47.*) "Hottest Flame Cuts Anything." The torch recently invented by Dr. Frank M. Strong of Syracuse University burns aluminum dust and oxygen. The inventor claims that the flame produced is hot enough to cut through any known substance.

(*P. 48.*) "The New Hydrogen Twins." Dr. K. F. Bonhoeffer of Germany described to the American Chemical Society at Minneapolis the process by which he separated two distinct forms of hydrogen and the experiments which reveal differences in their physical properties. It is interesting to note that the quantum theory furnishes a basis for the prediction of two such forms of hydrogen. (Photograph.)

(*P. 49.*) "A Universal Metal." At the recent meeting of the American Society for Steel Treatment, Dr. Zay Jeffries recounted some past achievements in alloy-making. An alloy harder than a steel knife, stronger than steel wire, as rustless as gold or platinum and as light as aluminum is not an improbable future development.

(*P. 55.*) "Detects Counterfeits in Ashes of Banknotes." By analyzing the ashes of some destroyed banknotes discovered in a counterfeiter's den R. M. Ghosal, principal of the Detective Training School at Insein, Burma, was able to prove that the notes had been spurious and to secure a conviction.

(*P. 61.*) "New Anesthetic Lessens Fear of Operation." A new local anesthetic—isoamylethyl barbituric acid—is said to be free from many of the ill effects produced by cocaine and procaine. The new anesthetic may be given by mouth or intravenously to produce part of a general anesthesia for major operations.

(*P. 61.*) "Produce Motor Fuel from 'Wild' Oil Well Gas." An electrical discharge method for producing gasoline from the gas which escapes from oil wells has been devised by S. C. Lind and George Glockler of the University of Minnesota. The method is not at present economically practical.

(*P. 61.*) "Hog-Stomach Extract Used to Treat Anemia." An extract made from dried hog-stomach was found by recent experiments at the University of Michigan to be more effective in fighting anemia than liver. The new preparation is tasteless and so highly concentrated that one ounce is equivalent to a pound of liver or three ounces of liver extract.

The extract does not constitute a cure for pernicious anemia, but an ounce a day is sufficient to relieve the patient's suffering.

(*P. 109.*) "Home Workshop Chemistry." Directions for the preparation of molding compositions for the preparation of plaster casts and other purposes.

SCIENTIFIC AMERICAN, *January, 1930*

(*P. 9.*) "Research Made Your Motor Car." *C. F. Kettering.* In addition to strictly engineering developments the author cites a large number of chemical achievements in the development of new materials and processes. These include: the development of lacquer, which made quick painting possible; the development of ductile tungsten, which made electric headlights possible; the development of the rubber tire, which made high-speed travel possible; the development of high-speed tool alloys which made low-cost, high-precision manufacturing possible; the compounding of alloys to meet special structural needs; the invention of "synthetic" fabrics; the improvement in the yield of gasoline from petroleum; etc. (Illustrated.)

(*P. 14.*) "Air." *Donald A. Laird.* The writer sets forth the results of modern studies on ventilation and on the physiological effects of varied atmosphere. It is only very rarely that air becomes unfit for breathing because of high CO_2 content or other "poisoning." Proper temperature, humidity, and some degree of motion are the criteria for health-sustaining atmospheres. The optimum temperature for schoolrooms, offices, and other places of sedentary occupation is about 67°F. Ventilation systems should draw off the air at the ceiling level rather than at the floor level, as is required by law in many states. (Illustrated.)

(*P. 42.*) "The Rarest Metal Yet Obtained." *Aristid V. Grosse.* Protactinium, recently isolated by the writer, is a strongly radioactive element. It is a metal, like radium, but much rarer and with an average life about twenty times as long. Protactinium is element 91, one of those foretold by Mendeléeff and by him called "ekatantalum." The writer outlines the theory upon which the isolation of the element was based and describes some of the actual laboratory manipulations involved. (Illustrated.)

(*P. 51.*) "Fused Quartz for Ultra-Violet Rays." Three photographs with an explanatory caption. These illustrations show trays of crushed quartz being placed in a furnace, plates of clear transparent quartz, and a quartz-glassed solarium on the roof of the National Vaudeville Artists' Sanatorium.

(*P. 60.*) "Defeating the Gasoline Knock." *Graham Edgar.* Constant supervision and testing are necessary to insure that the anti-knock compound, tetraethyl lead, is blended in correct proportions with raw

gasoline to produce an anti-knock fuel. One of the devices employed to this end is a gasoline engine with a double carbureter and valve connections which make it easy for the operator to shift from one fuel supply to another. By this means a gasoline may be treated with successively increasing proportions of tetraethyl lead until its performance equals that of a standard reference gasoline. Other devices and tests are discussed. (Illustrated.)

(*P. 74, et seq.*) "Chemistry in Industry." Includes the following items: "New Method of Curing Concrete Supersedes Usual Straw Covering." Sodium silicate is finding another use as a concrete-curing wash. (Illustrated.) "Humidity Affects Motor Performance." Excessive atmospheric humidity does make gasoline engines operate more smoothly but it also reduces power output materially unless the carbureter is adjusted to suit atmospheric conditions, according to the Bureau of Standards. "Superior Lacquers from Vinyl Resins." New synthetic resins which dry by polymerization as well as by solvent evaporation produce waterproof lacquers remarkably resistant to acids and alkalies. "Mineral Wool Made from Lead Slag." Another industrial waste is converted to profitable use—this time as a heat-insulating material. "'Eskimo Pie' Idea Applied to Wolf Poison." Bitter strychnine which wolves reject because of its taste is coated with a wax which prevents the animals tasting the poison but which melts at stomach temperatures. "Bacteria May Supply Chemicals." Butyl alcohol, a lacquer solvent, is already being produced on a large scale by fermentation processes. It is predicted that microörganisms will play an increasingly important rôle in the chemical industry of the future. "Diphenyl as a Heating Medium." Diphenyl is being used as a heating medium for Govers towers in petroleum refining. "Spectrum of Chlorine Gas." A new electrode tube, into which additional chlorine can be introduced as the original supply is exhausted by reaction with the electrodes, makes it possible to take very long exposures of the chlorine spectrum and hence to study regions which have heretofore been too weak to record. The lines obtained in this manner conform to theoretical predictions. "Steel-Coated Paper Money." By means of a new process paper money can be coated with a thin film of steel alloy, which increases durability and reduces the probability of forgery. "Synthetic Lacquer Has Synthetic Name." Glyptal, a synthetic resin, used in lacquers is named after the raw materials of which it is made—glycerine and phthalic anhydride. "Mold Used to Make Gluconic Acid." Mold fermentation processes for the production of gluconic acid have reduced the cost of calcium gluconate from $15 to 50 cents a pound. "Extend Investigation of Rare Gases." By combined processes of fractional distillation and adsorption a French chemist has succeeded in obtaining several liters of krypton and one liter of xenon from air. "Wanted: Uses for Columbium." Metallic columbium can now be produced at about half the cost of gold.

There is considerable speculation as to what uses will be found for it. "Chemical Jingles." "We Pay for Ashes." "New Uses for Stellite." Stellite, a cobalt-chromium-tungsten alloy, long used for cutting tools, is now being welded to iron or steel bases to furnish exceptionally wear-resisting surfaces for machine parts. "Electric Tester Shows Presence of Inflammable Gas." A device which detects the presence and percentage of inflammable gases in air by measuring the change in resistance of incandescent wire brought about through temperature changes caused by combustion of the gas. (Diagram.) "Phenol Prevents Mold on Leather." An effective treatment is to soak the leather in 0.2 per cent phenol solution. Addition of phenol salts to leather dressing is also suggested.

(*P. 89.*) "Beryllium for Aircraft." If beryllium can be reduced in price either by more efficient extraction methods or through utilization of by-products from beryllium ores, we will have another valuable material for airplane construction. It is estimated that a Ford tri-motored, all metal plane could be lightened by 1000 pounds if it could be built of beryllium-aluminum alloy.

SCIENCE AND INVENTION, *January, 1930*

(*P. 782.*) "Smoke." Smoke, in addition to its detrimental effect on health, actually costs the taxpayers of New York City about $96,000,000 a year. The Department of Health is combining a campaign of education with warfare against careless offenders. A quantitative check on sunshine is made by a "daylight recorder"—an apparatus which includes a light-sensitive cell and a recording mechanism. (Illustrated.)

(*P. 796.*) "What Boy Chemists Did." Edwin Israels, 18, and William Chudnowsky, 19, with the aid of friends, have built and equipped a laboratory at Middle Village, New York. They experiment mostly in biology and chemistry. (Photograph.)

(*P. 810.*) "How to Prepare Dyes and Pigments." *Eugene W. Blank.* Directions are given for the preparation of fluorescein, eosin, and canarin. (Illustrated.)

POPULAR MECHANICS, *January, 1930*

(*P. 7.*) "Wood Fuel Runs Army Truck by Generating Gas." Small blocks of wood are destructively distilled, and the gases used to operate the truck which carries the apparatus. (Photograph.)

(*P. 7.*) "Electric Ice Box Toots Horn When Gas Leaks." An automatic device shuts off the central refrigerating plant and sounds an alarm as soon as $1\frac{3}{4}$ pounds of gas have escaped from any unit in an apartment house or hotel. The system cannot be re-started until repairs are made.

(*P. 14.*) "Chemicals in Oil-Field Brine May Prove Valuable." Engineers at Oklahoma City have built a plant which they claim can extract

and purify NaCl, bromides, iodides, and other chemicals from oil-field brines at a profit.

(*P. 32.*) "Uninflammable Gas Used to Blast Coal." An account of the use of liquid CO_2 cartridges for coal blasting. (Illustrated.)

(*P. 33.*) "Gas Mantle Was Invented by Chance." Welsbach, while experimenting with a solution of thoria and ceria, allowed some of the liquid to boil over onto an asbestos pad. Noting the consequent incandescence at the edge of the pad he set to work to apply his discovery to practical use.

(*P. 39.*) "Fallen Leaves Worth Money Because of Chemicals." Leaves contain valuable plant foods which are partially lost when the leaves are burned.

(*P. 57.*) "Germs Cause Fires on Farms Is Theory of Chemist." Dr. C. A. Browne of the U. S. Department of Agriculture believes that spontaneous fires in hay and other farm products have their origin in heat released by bacterial action. Actual combustion is caused by aerial oxidation of certain products evolved by the bacteria.

(*P. 73.*) "Unique Mine Yields Silver, Gold, and Quicksilver." Not only the three metals listed above, but antimony and arsenic also, have been obtained in commercial quantities from a mine near Manhattan, Nevada.

(*P. 73.*) "Mouse Better Gas Detector than the Canary." Japanese dancing mice are found to be even more susceptible to carbon monoxide than canaries, which have previously been used to warn miners of the presence of this deadly gas. (Photograph.)

(*P. 89.*) "Artificial Air Supports Life Better than Normal Air." Experiments by Dr. J. Willard Hershey of McPherson College indicate that artificial atmospheres of oxygen and helium support life even better than ordinary air. Argon and oxygen were not quite so satisfactory.

(*P. 89.*) "Preventing Yellow Leaves." Application of copperas ($FeSO_4$) around trees whose green leaves turn yellow during the spring or summer has been found an efficient remedy for correcting this condition.

American Potash Production Increasing. The potash production from American mineral beds is increasing rapidly, but not as rapidly as the national demand for this important fertilizer. So reported Dr. J. W. Turrentine of the U. S. Department of Agriculture, speaking recently at Minneapolis before the fall meeting of the American Chemical Society.

The world production in 1928, he said, may be conservatively estimated at something over 1,900,000 tons of actual potash. In the United States production amounted to 104,000 tons of potash salts, equivalent to 60,000 tons of actual potash, valued at over $3,000,000. This represents an increase of 38 per cent over the previous year's tonnage. During the same period, however, 976,000 tons of potash salts, representing a total value of $22,500,000, were imported for domestic consumption. This represents an increase of 33 per cent in American importation'—*Science Service*

Correspondence

UNDERGRADUATE LABORATORY WORK AT HARVARD UNIVERSITY

Several of the difficulties ordinarily encountered in conducting undergraduate laboratory work in chemistry have been remedied by a plan which has been used for a number of years in the advanced courses of this department and has recently been successfully extended to the elementary courses. In most college courses in chemistry, each student is required to be present in the laboratory during specified hours, amounting to from three to nine per week in each course. The disadvantages incident to a rigid schedule of this kind include the difficulty of avoiding conflicts between the chemistry laboratory and other courses, a difficulty which frequently means several days of struggle with a refractory schedule at the opening of the college year. More important than this, however, is the fact that by the middle of the first term the students have advanced at widely varying rates. The quick workers, either the slap-dash or efficient, are performing experiments which may not be covered in the lectures for several weeks, and the slow students are hopelessly behind in their work. This condition greatly impairs the efficiency of the course, increasing the difficulties both to the students and the teaching staff. Furthermore, it is usually difficult, if not impossible, for a student to make up work missed through illness or other reasons.

These disadvantages have been obviated in this department by keeping all the undergraduate laboratories open for work approximately forty hours per week. Each student is assigned to one three-hour laboratory period per week at a specified time. During this period his section instructor is in the laboratory and the method of supervision and teaching follows that usually used. If the student does not complete the assigned experiments in the three-hour period, or if, as many do, he wishes to spend more time on the work, he is at liberty to work in the laboratory at any time that his desk is not in use. This, of course, does not mean that a student is allowed to postpone his laboratory work until the last few weeks of the term and then complete the experiments in the least possible time. Reasonably regular attendance is required and obtained. An instructor is on duty in the laboratory all the time that it is kept open in order to supervise the work. This is to ensure safety and order rather than to give personal instruction. In general, during the regular section periods the instructors take the initiative and go to the students to question, instruct, and assist. During the other hours the attendant instructor allows the students to work largely on their own, giving advice and so on only when the students

come to him. In order to make this plan feasible it is necessary that no more than two men need be assigned to each laboratory space, and that enough instructors are available to afford adequate supervision.

The advantages of this method are obvious. Aside from avoiding the difficulties mentioned above, it is more flexible and hence more agreeable both to students and instructors than the usual plan of definitely scheduled hours. Perhaps the greatest advantage is that more responsibility is given to the student in the arrangement and scheduling of his work. Students are encouraged to spend more time in the laboratory and, if they so desire, they may be allowed to do more advanced experiments than those assigned to the class as a whole. Finally, it is believed that better results are obtained by giving the students greater freedom in their work and creating and maintaining the impression that their work can be adapted to their personal needs rather than that it must conform to an arbitrary standard.

HUGH M. SMALLWOOD

HARVARD UNIVERSITY
CAMBRIDGE, MASS.

High-Grade Papers Made from Wood. High-grade bond and permanent record papers, where permanence and durability are essential, have always been made from cotton rag fibers. As a result of an investigation by the U. S. Bureau of Standards, however, it is indicated that certain types of highly purified wood fibers are suitable for conversion into such papers. This will effect considerable saving since the wood fibers are much less expensive than cotton fibers.

Papers carefully prepared from high-grade cotton rags have always been used exclusively where permanence extending over hundreds of years was desired. The cotton fiber is the purest form of cellulose found in nature, and cellulose, commonly called alpha cellulose, has a high degree of permanency.

Ordinary wood fibers, on the other hand, have impurities which seriously affect their permanence. By a series of chemical treatments these impurities can be removed, according to the Bureau of Standards, leaving a fiber similar in its chemical composition to the cotton fiber and having the desired paper-making characteristics.

Tests are being made at the Bureau of Standards of the various types of paper-making wood fibers and of several grades of rag fibers. The tests include purity, strength, and whiteness.

Complete information cannot be obtained by analysis alone. For this reason an accelerated aging test is considered a valuable supplementary test. This is made by heating the paper and finding the degree of deterioration of its physical and chemical properties. This treatment is presumed to simulate the chemical effect of many years of natural aging.

The fibers are baked in dry form at a temperature of 212°F., then they are cooked with steam, and are exposed to intense light rays from a carbon-arc lamp which acts as an artificial sun. After such severe treatment, the fibers are subjected to searching tests to find out how much they have deteriorated both chemically and physically.—*Science Service*

Chemical Digest

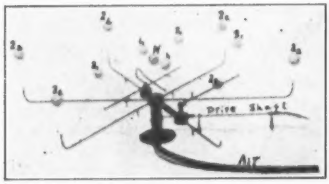
ABSTRACTS

APPARATUS, LABORATORY PRACTICE, AND DEMONSTRATIONS

A Dynamic Atom Model of the First Eleven Elements of the Periodic Table. J. G. BLACK. *J. Optical Soc. Am.*, **19**, 317–9 (Nov., 1929).—"The large central vertical shaft carries six radial arms of equal length. These arms are made of 1/4-inch brass tubing and are fitted with small nozzles from which issue jets of air. Attached rigidly to the large vertical shaft is a horizontal tube, 3/4-inch diameter, with small gear boxes at its ends. This tube is nine inches long, three inches being on one side of the center of the main shaft and six on the other side. The three-inch portion supports a gear box which drives the arm which carries the "elliptic" (2_1) electrons. The six-inch portion supports a similar gear box which drives the arm carrying the one "elliptic" (3_1) electron.

"The two nozzles above which the (2_1) electrons may be seen, move with uniform circular motion about their own axis which is itself moving with uniform circular motion about the central axis. The same type of motion is executed by the (3_1) electron.

"Immediately above the main vertical axis is suspended the nucleus, marked 'N,' and above the same horizontal arm are suspended the two (1_1) electrons of the K shell; then come the two (2_1) 'elliptical' orbits of the L shell; then the six (2_2) circular orbits of the L shell, completing the closed electron configuration for the neon atom; and last is the (3_1) 'elliptical' orbit of the M shell which extends beyond the (2_2) circle at aphelion and in close to the nucleus at perihelion, this being the valence electron of sodium.



DYNAMIC ATOM MODEL IN OPERATION

"Compressed air is furnished through the hose marked 'Air' and the rotation is produced by the drive shaft which is attached to a small motor.

"The apparatus is mounted on a sheet of varnished plyboard 36″ × 36″ for protection and support.

"A very interesting feature of the model is the manner in which the electrons are made to 'spin.' Some time was spent in trying to make the balls spin about a vertical axis but without success. While setting up the model for a demonstration lecture, however, it was thought advisable to incline the plane of rotation so that the students could get a better view of the orbital motions. This was done, and it was observed that the electrons began to spin; about an axis, however, parallel to the plane of the board. The spin is caused, of course, by the fact that the ball hangs to the lower side of the jet and the air passes to one side of it more than the other. This, of course, causes the spin vector (s) to be directed perpendicular to the orbital vector (l) and not parallel nor anti-parallel to it, which would be more desirable.

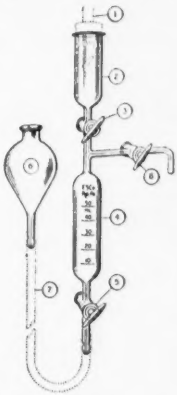
"The tilting of the board, however, and the resulting spin of the electrons brought out another interesting thing. The balls used are made of light celluloid and there is a band around the center where the two hemispheres are joined together. This band causes the ball to have its greatest moment of inertia about an axis normal to the great circle through the band, and when set to spinning the ball will be most stable when spinning about this axis.

"The result is that the spin axis seems to take a 'preferred orientation in space' and it keeps this same direction of spin as it moves around and around in its orbit. To bring out this odd feature, one-half of the ball is colored bright red and the other white. The white half always points toward one side of the lecture room and the red half to the other.

"The following fourteen features of atomic structure are brought out by the model: 1. The atomic constituents are moving in space. 2. The nucleus and electrons are very small compared to the size of the atom. 3. The electrons move in circles and 'ellipses.' 4. The perihelion and aphelion distances are not the same for the different

'ellipses.' 5. The (3_1) ellipse shows penetration into the L shell. 6. There is a progression of 'aphelion' for the 'elliptical orbits,' which in an atom is caused by the relativity change of mass. 7. The reason for the low ionization of the alkalies is shown. 8. The electrons are spinning. 9. The spin axis keeps a preferred direction in space. 10. All of the normal configurations of the first eleven elements of the periodic table may be represented. 11. Many of the excited states of the elements may be shown. 12. The symmetry of the rare gas configurations, helium and neon, is apparent and the reason for their inert character is obvious. 13. The reason for the electro-positive valency of sodium and the electro-negative valency of fluorine is apparent. 14. The idea of 'electron grouping' is shown." R. L. H.

A New Receiver Simplifies Vacuum Distillations. *Laboratory*, **2**, No. 5, 79 (1929).—"An ingenious receiver has recently been devised that allows any number of fractions to be conveniently withdrawn during vacuum distillation, without placing any extra load on the vacuum pump.



"The difficult part of the operation of separating fractions under reduced pressure has been the evacuation of the receiver and the withdrawal of the fractions therefrom.

"Referring to the illustration: (1) is the outlet of the condenser in which the distillate is condensed. This distillate drops into the upper chamber (2), of the apparatus and from thence passes through the stopcock (3) into the lower chamber (4). Chamber (4) is graduated to measure the volume of the fraction collected. When sufficient of the distillate has been received, stopcock (3) is closed, and during the withdrawal of the fraction, the distillate is allowed to collect in chamber (2).

"At the bottom of the chamber (4), is stopcock (5), connected to a mercury reservoir (6) by the heavy nitrometer tubing (7). By opening stopcock (5) the mercury displaces the distillate in chamber (4) and forces it through the delivery tube and stopcock (8) into the usual graduated cylinder. When the mercury has risen to the level of the delivery tube (8), stopcock (8) is closed and the mercury in chamber (4) is lowered below stopcock (5) which is then closed. Chamber (4) is thus evacuated and, on opening stopcock (3) the distillate which has meanwhile collected in chamber (2) flows into chamber (4) to form part of the next fraction."

The cost of this Ashworth Receiver is approximately thirteen dollars. H. H. K.

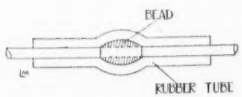


FIGURE 1

A Seal for Electrodes. S. MUNDAY. *J. Sci. Instruments*, **6**, 360–1 (Nov., 1929).—"A very efficient type of seal for electrodes, especially when in the form of thin wires, may be made in the following manner.

"A small egg-shaped bead is turned and a hole of suitable size for the wire is drilled along the major axis. The bead is then soldered on the wire. A thin rubber tube is slipped over both bead and wire; bicycle valve tubing is very suitable (Figure 1). The hole in the wall of the vessel into which the electrode has to fit should be tapered (Figure 2) and of such size that the bead, when the rubber tubing is stretched over it, will stop about midway along the hole.

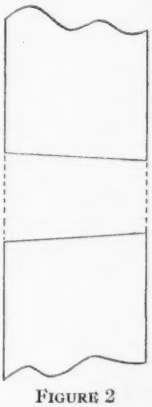
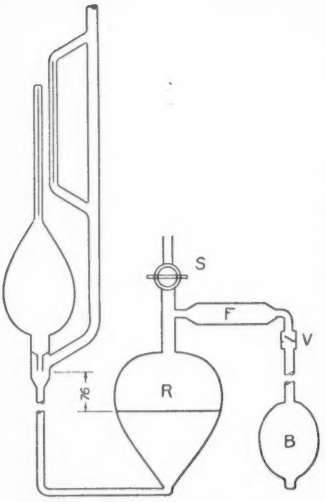


FIGURE 2

"To assemble the seal the rubber should be stretched fairly tightly over the bead and wire, the whole pulled into the tapered hole and then, when the bead is wedged, the rubber tube at the big end of the hole should be allowed to spring back. The big end of the hole should, of course, be on the 'pressure' side of the apparatus.

"The writer has made many of these seals, some of them holding up to pressures of 1100 lb./sq. in. with satisfactory results." R. L. H.

A Pressure Controlled McLeod Gauge. N. UNDERWOOD. *J. Optical Soc. Am.*, **19**, 78 (Aug., 1929).—"If the vacuum goes bad or is not controlled properly on either side of a vacuum controlled McLeod gauge, disastrous results follow. In order to avoid this



difficulty a gauge was made in which the mercury was controlled by the converse method. It was found that an atomizer bulb with good valves (one with rubber valve is satisfactory) would produce a pressure of 50 or 55 cm. of mercury. Usually a McLeod gauge can be made so that the necessary motion of the mercury is well within this limit.

"In the arrangement here shown the usual glass tube coming from the gauge proper goes to a mercury reservoir *R* which is at such a level that when the gauge is evacuated, the mercury column comes to rest at a point just below the side tube. With the stopcock *S* closed, the atomizer bulb *B* will furnish sufficient pressure to move the mercury to any desired height in the gauge. Opening the stopcock *S* relieves the pressure, and the mercury comes back to its normal position. *F* is an air filter to prevent contamination of the mercury. The valve *V* should hold fairly well. It was found that an automobile tire valve with its spring weakened (by heating), and its seat greased with stopcock grease, would work.

"This method of moving the mercury can, of course, be applied to mercury shutoffs, etc., in which case the valve *V* had best be replaced by a stopcock. It seems to have a slight advantage over the method described by Dr. Donald L. Hay [*J. Optical Soc. Am.*, **7**, 1015 (1923)] in that there are no moving parts, the over-all height of the gauge is less, and it possesses the same advantage of cleanliness." R. L. H.

Preparation of Very Pure Platinum Sponge. *J. Frank. Inst.*, **208,** 804 (Dec., 1929).—The preparation of about 500 g. of very pure platinum sponge has just been completed, according to a note from the U. S. Bureau of Standards, by the following process; starting with scrap platinum containing about 5% impurities which included iridium, rhodium, palladium, ruthenium, gold and iron, the gold was first precipitated by ferrous sulfate, then the iron and other impurities were precipitated by sodium bicarbonate added to the boiling solution until faintly alkaline. Sodium bromate had been added previously to retard the action between the platinum and sodium bicarbonate. In the filtrate from the precipitation, platinum thus obtained was 99.999% pure. Two ammonium chloride precipitations were made for the purpose of eliminating sodium chloride. This method, although requiring some experience in manipulation, is very well suited to the rapid preparation of very pure platinum on a laboratory scale. J. H. G.

An Adjustable Mounting for Wall Galvanometers. J. SMYTH AND S. W. TAYLOR. *J. Optical Soc. Am.*, **19,** 93–4 (Nov., 1929).—The mounting consists of three castings; the main casting is attached to the wall, the galvanometer is attached to another. The third casting is used to join the galvanometer to the frame or base on the wall, the joints being adjustable. The telescope frame is hooked to heavy brass strips which are attached to the main casting. The three main features are: (1) ruggedness, (2) slow motion adjustment about both horizontal axes and (3) reading telescope is attached to the main casting instead of to galvanometer. R. L. H.

Instruments and Methods Used for Measuring Spectral Light Intensities by Photography. *See same title under* **Scientific Reviews and Bibliographies, page 461.**

The Caesium-Magnesium Photocell. V. ZWORYKIN AND E. D. WILSON. *J. Optical Soc. Am.*, **19,** 81–9 (Aug., 1929).—The values of the work functions of the alkali metals and their color-sensitivity curves indicate definitely that caesium is the most favorable material for use in photocells.

The practical difficulties of handling caesium metal have been overcome in the caesium-magnesium cell, in which a freshly evaporated coating of magnesium not only binds an invisible layer of caesium to the walls of the cell, but also provides an electrical connection with the cathode terminal.

Average color-sensitivity curves are given for more than twenty cells. They show

that the maximum sensitivity lies at about 4850A, as compared with 4400A for pure potassium, 5390A for pure caesium, and 5560A for the human eye.

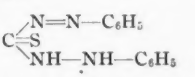
The photoelectric properties of the cell are detailed by means of response-voltage curves, response-illumination curves and illumination limit curves. The maximum response for vacuum type cells is about 2 microamperes per lumen, and for gas-filled cells about 25 microamperes per lumen under normal operating conditions.

Several commercial applications are described. Further development work is now in progress. R. L. H.

Simplified Determination of Trivalent Arsenic. G. FESTER. *Z. angew. Chem.*, **42**, 1040 (Nov. 2, 1929).—Arsenic is determined usually in the following manner in Schweinfurt Green and similar substances: The material is destroyed by boiling with NaOH; any pentavalent arsenic is reduced with HI; excess I is removed with $Na_2S_2O_3$ and the trivalent As is titrated against I in the presence of $NaHCO_3$. This method is very complicated and gives unreliable results if the commercial product contains Ca compounds as calcium arsenite is not completely decomposed by boiling with NaOH.

The following method gives reliable results and can be performed in a few minutes. The sample is dissolved by heating with hydrochloric acid and the solution is diluted with a large quantity of water. Without filtering add a solution of $(NH_4)_2CO_3$ until the copper-containing precipitate has redissolved. Titrate finally with $N/10$ I solution until the bluish solution assumes a green color. The end-point is very definite and good checks can be obtained. L. S.

The Detection of Heavy Metals by Means of "Dithizon." (Diphenyl-Thiocarbazon). H. FISCHER. *Z. angew. Chem.*, **42**, 1025–7 (Oct. 26, 1929).—Diphenylthiocarbazon or Dithizon of formula



is a derivative of thiourea and phenyl hydrazine and possesses a constitution which enables it to form very stable complex compounds with the heavy metals. The coördination chemical property of "Dithizon" has not been explained yet. It is possibly due to the doubly bound nitrogen. It may also be that the sulfur plays the rôle of a connecting link for the formation of stable five-membered rings.

Such complex compounds are precipitated when an alkaline or ammoniacal solution of dithizon is added to an aqueous solution of a salt of a number of heavy metals. These precipitates vary in color and are highly insoluble in water. Typical for the complex nature of these compounds is the fact that many of them are highly soluble in organic solvents like chloroform, carbon tetrachloride, carbon disulfide, etc. These solutions are intensively colored and the colors are characteristic for each metal. The secondary valences of these metals in the dithizon compounds are saturated as shown by the great stability of these compounds toward aqueous ammonia in which they are insoluble even if the metal forms normally ammonia addition compounds like silver, copper, zinc, etc.

The following metals form such compounds: Group O: none; Group I: Cu, Ag, Au; Group II: Zn, Cd, Hg; Group III: Tl; Group IV: Sn, Pb; Group V: none; Group VI: none; Group VII: Mn; Group VIII: all metals.

There is a fundamental difference in the behavior of the alkali metals and the subgroup *B* of Group I toward dithizon. The alkali metals form red derivatives which are very soluble in water and insoluble in organic solvents. The solutions show all the properties of a normal salt with respect to dissociation and reactions. The derivatives of Cu, Ag, and Au are insoluble in water; the Au compound is yellow, that of Ag reddish brown, and that of Cu brownish black. All three compounds are insoluble in aqueous ammonia while only Au dithizon is soluble in organic solvents.

The metals of Group II behave similarly. The derivatives of Zn, Cd, and Hg are very stable, vary in color from violet to orange, are insoluble in water and aqueous ammonia and dissolve easily in numerous organic solvents. The solution of the Zn compound in carbon disulfide is purplish red, that of Cd is raspberry red, and that of divalent mercury orange red. The earth alkali derivatives are analogous to those of the alkali derivatives. The metals of Group III seem to have no tendency to react with dithizon. A very feeble reaction of thallium is probably due to contamination with Pb. In and Ga have not been investigated as no pure derivatives were available. In Group IV only Sn and Pb reacted. Their compounds showed the same typical complex properties. No derivatives could be obtained in the Groups V and VI. In Group VII, only Mn formed a compound which is not very stable. All metals of Group

VII form such complex compounds with the exception of trivalent Fe. Divalent Fe forms such a derivative.

This remarkable tendency of dithizon to react with these metals to form compounds which are distinguished by their characteristic reactivity offers a possibility to use them for analytical purposes as the solutions obtained are so intensively colored and the colors vary decidedly according to the metal. These color reactions are obtained when a very dilute solution of dithizon in carbon disulfide or carbon tetrachloride is shaken with an aqueous, approximately neutral, solution of a salt of one of the metals mentioned. These two solvents are turned green by traces of dithizon. On the addition of the salt solution the intensively green color is changed to brown, orange, red, violet, etc., according to the metal present. In the case of Au and Ag, the green color disappears and yellow Au dithizon or brownish violet Ag dithizon precipitates out. The sensitiveness of these color reactions is so great that $^1/_{1000}$ mg./cm.^{3} of a metal can be detected very easily. This sensitiveness can be increased by the use of a faintly green dithizon solution and very pure distilled water.

The affinity of the various metals for dithizon varies and is greater in the first two groups than in all others even if the other metals are present in excess. In this way, Au can be detected in the presence of all metals except Hg and the Pt metals; Ag in the presence of all metals except Au, Hg, and the Pt metals; Hg in the presence of all metals except Cu and the noble metals; Cu in the presence of all metals except Hg and the noble metals. The presence of Zn can be detected in the presence of Co, Ni, Fe, Pb, and all other metals which form no derivatives with dithizon.

Various other possibilities are suggested; *e. g.*, when the aqueous salt solutions are treated with excess KCN before shaking with dithizon, then the reactions are negative except in the case of Pb and Zn while potassium dithizon dissolves in the water with a yellow color. This property should facilitate greatly the detection of these two metals. Co can be detected in the presence of Ni and all other metals except Hg, Cu, and the noble metals by treating a dilute ammoniacal solution of the Co salt with a few cubic centimeters of a very dilute orange-yellow solution of dithizon in aqueous ammonia; the solution becomes reddish violet. If an alkaline Co salt solution is treated with a solution of dithizon in dilute NaOH, then the solution is turned bluish violet which changes soon to a grayish color. There are many other possibilities. L. S.

Working with Mercury. ALFRED STOCK. *Z. angew. Chem.*, **42**, 999–1001 (Oct. 19, 1929).—The dangers of mercury poisoning are still underrated in many laboratories. The following symptoms can be observed according to recent observations by Dr. Holtzmann [*Zentralblatt Gewerbehygiene Unfallverhüt.*, **16** (1929)]: headaches, fatigue, excitability, inflammations, bleedings, abscesses of the gums, loosening of teeth, diarrhea, etc. Holtzmann concludes that mercury poisonings will occur sooner or later in all laboratories in which the most careful precautions are not taken when working with mercury.

The question is: How to protect from the dangerous effects of this element? The mercury content in a given room can be reduced by (1) removing all loose and visible mercury, (2) covering the floor with linoleum (3) cementing all cracks and fissures, (4) continuous airing, (5) painting of the walls and ceiling with oil paints. The effectiveness of this treatment can be seen from the following example: The wooden floor of an office contained so much mercury that the air of this room contained $^2/_{10,000}$ mm. Hg per cubic meter. After making the above corrections no more mercury could be detected in the air even qualitatively.

Mercury must everywhere be used as the dangerous poison which it is and as which it was handled by our predecessors, the generation of Bunsen and Hempel, and should never be treated like water as it is being done lately. There should be no exposed surfaces of mercury. Such surfaces should be kept under a hood or else be covered up with water, paraffin, or the like. If possible all work with this metal should be done in a special laboratory equipped for this purpose. A number of illustrations are given to show how all these ideas have been worked out in Karlsruhe laboratory.

Above all, the primary requirement is effective airing. In spite of its known defects as sensitiveness against heat and alkalies, linoleum is best for rooms in which work with mercury is to be done. The surface of the linoleum should not be oiled but waxed evenly. It should be protected carefully against cracks from nails, pieces of glass, etc. Pieces of apparatus should not be attached to ring stands below which this element is likely to collect but to clamps fastened to the wall. L. S.

Carbide Gas for Rural Schools. M. E. DILTS. *Pract. Home Ec.*, **7**, 239 (Aug., 1929).—This article points out the advantage of carbide (acetylene) gas for use in laboratories and cooking schools where other methods of heat are not readily available.

The generator uses gravity as its motive power and its operation is entirely automatic. A 200-lb. charge of carbide will furnish 900 cu. ft. of gas. A single hot plate burner of five flames costs 3.8¢ an hour and will heat a quart of water to boiling in 10 minutes. A well-insulated oven will heat to 400°F. in 12 minutes. It can also be used in a gas iron or for lighting. J. W. H.

TEACHING OBJECTIVES, METHODS, AND SUGGESTIONS; CURRICULA

The Motion Picture and the School. B. A. AUGHINBAUGH. *High Sch. Teacher*, 5, 310–1 (Nov., 1929).—Man first communicated by gestures, then these were supplemented and almost supplanted by speech. Neither of these can be passed on, so records that can bridge time and space were developed. First perhaps was the pictograph, then the ideograph, then phonographs, sound pictures, and finally the alphabet which is nothing more than sound symbols.

The change from pictures to alphabetical symbols was essentially the change of the man from artist to poet.

Science and its method came into the world with Francis Bacon. The scientist required detailed facts. He left nothing to chance. "The scientist told things, the poet told about things... In one case we are given experience from which we are to produce thought, in the other we are given thoughts which we interpret by experiences... The former process more nearly fits the definition of education.

The scientist sought to use the poet's sound symbols to meet his expressional needs but soon found them inadequate and presently reverted to pictures. In his efforts to produce pictures with accuracy and speed photography was born. Then the stereoptican came and in due time the movie. This last was long overdue when it arrived and was received as meeting " the longing of a million million years."

Just as the typewriter and the calculating machine have lessened the high importance of two of the "three R's," so the movie-tone may in time displace the third by bringing news, entertainment and instruction to the individual through the moving picture and the reproduced voice. B. C. H.

Chemical Engineering in North Carolina University. F. C. VILBRANDT. *Chem. & Met. Eng.*, **36**, 682–3 (Nov., 1929).—Specialization is necessary for the developing of the broad field of chemical engineering, for which fundamental academic training is demanded. Educational institutions must provide proper facilities for this demand. To this end the University of North Carolina established an engineering curriculum in September, 1925. The courses offered attempt to effect the following objects. "(1) To supply the substratum of fact that may serve as a basis, and tools that may serve as a means for developing analytical reasoning and expression. (2) To develop the proper attitude of mind toward the profession. (3) To supply inspiration and guidance in translation of chemical thought into action and accomplishment. (4) To supply training in the use of all tools that will assist in translating thought and work into permanent records. (5) To develop the proper perspective of the chemical industries along economic and humanitarian lines." R. L. H.

KEEPING UP WITH CHEMISTRY

The Newest Development of the Electrolytic Manufacture of Hydrogen Peroxide. L. LÖWENSTEIN. *Chem.-Ztg.*, **53**, 821–2 (Oct. 23, 1929).—Nature succeeds in making large quantities of hydrogen peroxide from water and air. The atmosphere contains 4×10^{-10} grams H_2O_2 per liter. This method cannot be duplicated in industry. Attempts have been made to make Thénard's method a cyclic process in which the raw products are recovered. Barium peroxide is treated with nitric acid; the barium nitrate formed is decomposed to barium peroxide by heating; unfortunately it is not possible to convert quantitatively the gases formed to nitric acid. Other attempts were made with barium carbonate. The salt was decomposed into barium oxide and carbon dioxide; the barium oxide was oxidized to barium peroxide which in turn was treated with water and carbon dioxide to give barium carbonate and hydrogen peroxide. This method does not yield a high-grade product as the conditions are not very favorable for the heat decomposition of barium carbonate. All the solutions of hydrogen peroxide obtained by the use of barium peroxide are never very pure no matter which method is used. Attempts to prepare it from water and oxygen or hydrogen by the use of the dark discharge or ultra-violet light were unsuccessful due to the large consumption of electrical power. A direct method, namely the electrolysis of acidified water, yields only very dilute solutions containing $^1/_2$ to 3% H_2O_2. An indirect electrical method is much more promising for industrial purposes. Persulfuric acid or its salts are pro-

duced at the anode. Hydrogen peroxide is distilled off together with steam, and the residue is subjected to electrolysis again. This is a cyclic process during which only water is used up. The following equations show the characteristic reactions:

$$H_2O = H_2 + O$$
$$2\,H_2SO_4 + O = H_2S_2O_8 + H_2O$$
$$H_2S_2O_8 + 2\,H_2O = 2\,H_2S_2O_4 + H_2O_2$$

also

$$(NH_4)_2SO_4 + H_2SO_4 + O = (NH_4)_2S_2O_8 + H_2O$$
$$(NH_4)_2S_2O_8 + 2\,KHSO_4 = K_2S_2O_8 + 2\,(NH_4)HSO_4$$
$$K_2S_2O_8 + 2\,H_2O = 2\,KHSO_4 + H_2O_2$$

This new method yields very high-grade products of hydrogen peroxide.
L. S.

Alumina Production in Its Present-Day Aspects. J. D. EDWARDS AND R. B. MASON. *Chem. & Met. Eng.*, **36,** 674–7 (Nov., 1929).—The cost of labor and chemicals prohibits extraction of aluminum from clay and ores low in aluminum (10%–35%). When alumina is converted into aluminum by electrolysis a considerable percentage of impurities is left in the metal in the form of an alloy. The purification is a relatively expensive process for about 2 lbs. of alumina is required to produce 1 lb. of aluminum. Alumina is purified by treating it with alkali and converting it into sodium aluminate, which is soluble in water. The solution is filtered, separating the Fe, Si, and Ti. The hydrate is formed, process repeated, and the Al_2O_3 dried for production of aluminum. Some Si is attacked by the alkali and often gives trouble and causes loss of both soda and alumina. Descriptions of the various alkaline processes are included.
R. L. H.

Varied Application Characterizes Aluminum in Industry. P. V. FARAGHER. *Chem. & Met. Eng.*, **36,** 543–5 (Sept., 1929).—No metal resists all forms of corrosion. One or more materials are particularly adapted to each individual type of corrosion. Wherever aluminum may be used it presents valuable combination of mechanical properties as easily worked or casted, low specific gravity and high resistance to corrosion. Commercial aluminum has a purity specification of 99%, the chief impurities being Cu, Fe, and Si. Alloying elements lower resistance to corrosion of aluminum except Mn. Many failures in use of aluminum have been traced to low-grade metal or use of an alloy not adapted to the requirements. The presence of small amount of sodium silicate inhibits the corrosion of alkaline substances on aluminum. Aluminum is unaffected by pure water. Aluminum ware is standard for use in handling of nitric acid made from atmospheric nitrogen, but is attacked by nitric acid made from Chile saltpeter, the latter probably due to presence of iodides and chlorides. Electrolytic corrosion may result from contact of aluminum with a metal higher in the electromotive series. The actual trial of the metal is the only test of service that is dependable. The author gives a list of chemicals and their reaction upon aluminum. R. L. H.

Beryllium. M. MERLUB-SOBEL. *Metals & Alloys*, **1,** 69–70 (Aug., 1929).—Beryllium has remained an element of mystery for almost 150 years, and considered as rare due to the difficulty of isolating it in the pure state. The ore is comparatively plentiful and ranges in price from 38¢ to 67¢ per pound. The necessity of the metal in the aeronautical era with the development of the high-temperature electrolysis of the alkali and alkaline earth beryllium fluorides has brought the metal within the commercial field. The metal as produced by the American process runs in purity well over 99% beryllium. There is yet about 0.20% iron remaining as an impurity which is soon expected to be entirely removed. The alloys of beryllium show marked improvement after treatment. Beryllium added to aluminum raises the strength of aluminum and the resistance to corrosion. The low specific gravity of Be-Al alloys makes this an ideal metal for aeronautical appliances. The now high price of $200 per pound is expected to be reduced to $5 per pound as the demands increase to 100 tons per year.
R. L. H.

Chromium Irons and Steels Exhibit Widely Varying Properties. W. M. MITCHELL. *Chem. & Met. Eng.*, **36,** 532–5 (Sept., 1929).—A discussion of the qualities of chromium irons and steels as to hardness, corrosion resistance, permanent luster, stainless, and general use in high-pressure apparatus. R. L. H.

Lithium; Its Extraction, Properties and Uses. G. M. DYSON. *Chem. Age, Mo. Met. Sect.*, **21,** 25–6 (Oct. 5, 1929).—Lithium is widely distributed in nature, but only in small percentages. The principle ores are complex silicates from which lithium sulfate is formed by fusion with barium carbonate and potassium sulfate. The lithium sulfate is then converted to the chloride from which the free metal is obtained by elec-

trolysis of the molten salt. The properties and some of the uses, especially those relating to alloys with aluminum, are described. E. R. W.

Tantalum—A Metal for Difficult Corrosion Problems. C. H. JONES. *Chem. & Met. Eng.*, **36**, 551 (Sept., 1929).—Remarkable strides have been made in the introduction of tantalum into industry. The cost of tantalum is one-fourth that of gold, but its characteristics justify the cost where it may be used. The main use of tantalum in the past has been in electrolytic rectifiers and in vacuum tubes or radio sets. Tantalum is being introduced as a material for spinnerettes in production of rayon. In addition to corrosion resistance the metal may be coated with an electrolytic oxide of almost diamond hardness which is resistant to aqua regia and toward wet or dry chlorine, and may be attacked only by fused caustic, HF, mixture of HF and HNO_3, and 95% boiling sulfuric. R. L. H.

Bingham Canyon's Great Copper Camp. Part I. R. G. SKERRETT. *Compressed Air Mag.*, **34**, 2917–21 (Nov., 1929).—Eight per cent of the world's supply of copper comes from this mine, from deposits which require the working of two tons of rock and ore for every twenty pounds of copper. This well-illustrated article deals with the history of the development of the mine. E. R. W.

How Amber Is Obtained. GRUNOW. *Pädagog. Warte*, **36**, 1007–13 (Nov. 15, 1929).—In Germany some amber is obtained by catching it in nets in the Baltic Sea. The best time of the year is the late fall when storms agitate the water. If the direction of the wind is favorable then a few people can collect between a few hundred to several thousand kilograms of amber in one day during this season.

The largest part of German amber is obtained in a mine at Palmnicken in East Prussia. This mine is unique in being the only amber mine in the world. The amber is located in a layer of blue earth not very far from the surface. 1000 cbm. of this blue earth contain approximately 1 kg. of amber. The annual output of this mine is 500,000 kg. of amber which involves the removal of 2–3 million cbm. of ground. Numerous borings have shown that the blue earth extends over hundreds of square kilometers and that the supply of amber is tremendous. For the purpose of isolating this amber the blue earth is brought to the surface and then washed downhill with powerful streams of water. The water breaks up the ground which is carried down into the sea while the amber is caught in series of sieves. The pieces of amber vary from the size of a rice grain to the size of a child's head. They are then sorted according to purity and clearness. The inferior pieces are collected in iron pots and melted. Vapors escape which are condensed to an oil. Succinic acid (German: *Bersteinsäure* = acid of amber) gradually crystallizes from this oil. The remaining residue in the pot hardens to a viscid, resinous mass of dark brown color, called amber colophony. This colophony is valuable for the preparation of floor varnishes; the oil is used for the manufacture of lacquers. The larger pieces of amber are polished by means of water and sand in large, wooden rotary drums.

Sometimes a piece of amber contains an insect enclosed. The museum of Königsberg values a piece containing a small lizard. The amber which is found nowadays was produced in the form of rosin in coniferous trees during the tertiary period of the Cenozoic era. This golden-yellow rosin dropped to the ground and occasionally enclosed a small animal. During the long period of time with its many changes produced by ice, water, and variation in temperature, the hardened amber became covered with layers of sand and clay. L. S.

Cellulose Acetate for Films, Rayon, and Plasters. *Chem. Met. & Eng.*, **36**, 671 (Nov., 1929).—Eastman Kodak Co. entered into the wood chemical industry for the purpose of assuring itself of a supply of ingredients of materials used in manufacture of photographic films—methanol and acetone. In recent years acetic acid and acetic anhydride have become of importance in the manufacture of cellulose acetate. The manufacture of these products is carried on chiefly at Kingsport, Tenn., so that the center of manufacture will be at the center of raw materials. R. L. H.

Uses for Rubber Latex. J. ROSSMAN. *India Rubber World*, **81**, 67–8 (Nov., 1929).—Method of electrodeposition of latex to form cork-rubber, shoe sole composition, artificial gut, molded articles, aircraft covering, abrasive articles, etc. C. W. E.

Uses of Rubber in Modern Aircraft. J. F. HARDECKER. *Rubber Age*, **26**, 29 (Oct. 10, 1929).—Interesting information concerning new articles and uses of rubber goods designed for aircraft, such as balloon fabrics, parachutes, air cushions, goggles, etc. C. W. E.

Making Rubber Goods of Latex by Electro-Deposition. P. KLEIN. *Rubber Chem. & Tech.*, **2**, 278–84 (Apr., 1929).—Present manufacturing methods are characterized by repeated plasticizing or rubber. Involves extensive and expensive machinery.

Rubber latex, a colloid, is preserved by NH_3 and shipped from the source as a fluid. Electric current passing through commercial latex causes rubber particles to migrate toward anode, where they coagulate. Cataphoresis, at first a troublesome hindrance, has been overcome by cell construction and manipulation. Pigments also are made in the form of suspensions, which are incorporated with rubber particles to form standard rubber stocks. Method valuable because of adaptability to irregular forms.

C. W. E.

Rubber Canvas Footwear for 1930. ANON. *Rubber Age*, **26,** 140 (Nov. 10, 1929).—New style features, trimmings, sole, and color designs predicted as given by interview with leading rubber companies. C. W. E.

Natural Gas and Its Uses. *Syn. Org. Chem.*, **3** (Dec., 1929).—A brief article concerning the source, production, and many uses of natural gas. H. H. K.

Transparent Emulsions of Some Essential Oils. W. F. WHITMORE AND R. E. LINEHAN. *Ind. Eng. Chem.*, **21,** 878–80 (Sept., 1929).—Emulsions of essential oils dispersed in concentrated aqueous sugar solutions are well adapted for flavoring products composed largely of sugar. For this purpose transparent emulsions, made by equalizing the refractive indices of the dispersed phase and the dispersion medium, are preferable to the usual cloudy emulsions. It was found that by using a concentrated solution of invert sugar or two parts invert sugar and one of sucrose as the dispersion medium its index of refraction could be made the same as that of the oil to be emulsified, producing a transparent emulsion. Emulsions of 5% orange, peppermint, rose, and lemon oils were prepared by passing through a homogenizer using various peptizing agents, gelatin proving to be best. A homogenizer is essential for stability, since the smaller particles produced present a larger surface for adsorption of the peptizing agent, exert less attractive force on each other, thus promoting a greater degree of stability. Emulsions made from invert sugar showed a tendency to grain. By using the mixture of two parts invert sugar to one of sucrose and 0.25% gelatin, emulsions that were still stable after eleven months were produced. D. C. L.

The Unknown in Silicates. *Silicate P's & Q's*, Nov., **1929.**—Interest is not a matter of subject—but of people. There is an attitude in natural science which questions every common thing; often vital discoveries result. Soluble silicates present a fruitful field awaiting scrutiny. Previous issues of *P's & Q's* have offered "applications of soluble silicates in industry—some new, some obsolete, some venerable but of daily value in our busy world." The current issue offers a group of problems awaiting solution.

It would be interesting to know how to stop the drying of soluble silicates so that there is preserved between the minute particles of the solution that degree of attraction which gives a solid film and at the same time provides flexibility. Silicate solutions can be neutralized but in so doing the value of the solution as adhesive material is destroyed. There ought to be some non-alkaline material which would disperse silica in such a way that it could be used on substances which are impaired by even a slight alkalinity. Solubility studies present interesting problems. At present, "neither the silicate solution which of itself dries to a perfectly insoluble condition, nor the one which once dried hard on a glass window pane can be easily and quickly removed" is known. Silica in solution is known to be useful in protecting metals from corrosion in liquid solutions where it forms a thin surface film, but how and why is unknown.

Impossible things are being accomplished daily, but are accomplished not by one—but by many. H. T. B.

Water, Water, Everywhere. A. S. BEHRMAN. *Chem. Bull.*, **16,** 311–4 (Nov., 1929).—Physical chemistry has made valuable contributions to the accurate understanding of the principles underlying the methods of water purification. Water for large communities must be clarified and sterilized by virtue of its surface source.

Aluminum sulfate was found to provide a better and faster method for filtration than the old method involving the settling out of mud on the filter bed, and at a pH value, not alkaline, but slightly acid—5.5 to 6.5. "Chlorinated copperas" is much used, and the method has been improved by adding ferric salts in place of ferrous salts. Hydrolysis and the formation of the desired ferric hydroxide take place within the range of pH values possessed by natural waters. Sodium aluminate is proving a useful reagent in certain fields. Offensive tastes and odors due to phenols, chlor-phenols, and chlorine may be removed by certain activated carbons.

Softening of water by the lime soda process has been improved by removing the colloidal calcium carbonate and magnesium hydroxide by (1) use of coagulants, (2) adding some of the previously precipitated calcium carbonate and magnesium hydroxide sludge, and (3) the use of excess reagent. A satisfactory explanation for the

zeolite process remains to be brought forward; one possibility is selective ionic adsorption but more evidence is needed. The Electro-Osmose process brought from Germany promises a solution of certain problems which previously required thermal distillation. H. T. B.

Creosote Oil Gives Timber Longer Service Life. S. W. LABROT AND F. A. DENCER. *Compressed Air Mag.*, **34**, 2929–32 (Nov., 1929).—An illustrated article describing the process of impregnating timber with creosote oil to slow down the rate of decay and to help keep out wood-eating worms and insects. From five to twenty-four pounds of oil per cubic foot of wood is used, the amount depending on the kind of wood and the use to which it is to be put. E. R. W.

Food-Coloring Practice in Canada and the United States. L. WHINYATES. *Chem. Age., Dyestuffs Mo. Sup.*, **21**, 27–8 (Oct. 12, 1929).—Over 95% of the coloring matter used in food at the present time is prepared synthetically. The United States has a list of fourteen dyes which may be used to color foods; not only are these colors harmless to the consumer but they are dyes which may be easily identified and distinguished from other colors. Canada has a list of twelve permitted colors of which ten are in the United States list. Some of these dyes and their uses are briefly discussed. The need for uniform regulations among different governments is desirable. E. R. W.

Chlorate Explosives. *J. Frank. Inst.*, **208**, 813–8 (Dec., 1929).—The Bureau of Mines is not infrequently called upon to give an opinion, usually to quarrymen, on an explosive offered for use. The chemical and explosive properties of perchlorate are discussed. Reference is made to Berthollet's attempt in 1788 to use perchlorate for the manufacture of gunpowder with its fatal results at Essone. Perchlorate is extremely sensitive to explosion by friction, percussion, concussion, ignition, or by contact with free acid. It will also explode by itself when the melted salt is dropped on red hot iron. Explosion by friction is a dangerous characteristic for explosives which are to be forced into a bore hole. The Broomstick Friction Test of Dupre is approved, but the Bureau of Mines has constantly and successfully used the Pendulum Friction Device developed in 1911. Of the hundreds of mixtures using chlorates, rack-a-rock and cheddite seem to have met with the greatest measure of commercial success. To blast Flood Rock at Hell Gate, N. Y., October 10, 1885, 240,000 lb. of rack-a-rock were used. Cheddite is a mixture of nitro-substitution compounds with perchlorate. The qualifications for various chlorates and perchlorates in explosives are discussed. Under the law, the Director of the Bureau of Mines officially approves explosives which pass permissibility tests and authorizes their publication on the *Permissible List* with a record of the test data for their more important characteristics, but no authorization for approval or publication exists for other explosives than *Permissibles*. J. H. G.

Glass Bubbles for Incandescent Lamps. R. G. SKERRETT. *Compressed Air Mag.*, **34**, 2889–96 (Oct., 1929).—This article describes the manufacture of bulbs for incandescent lamps. Although a few bulbs are still blown by men, by far the greater proportion of those used are blown by machinery. One machine, the fastest in the world, blows 250 bulbs a minute, 360,000 every 24 hours, requiring from 40 to 45 tons of glass. E. R. W.

Blasting Down Coal with Liquid Carbon Dioxide. *J. Frank. Inst.*, **208**, 819–20 (Dec., 1929).—Blasting with liquid carbon dioxide has been simplified, according to a note from the Bureau of Mines, by a reduction in the size of the shell. Such a shell is listed as safe with the Bureau of Mines. The use of carbon dioxide as a blasting agent is made possible by first liquefying it under pressure and then charging it into a hollow steel cylinder whose outside diameter is 3 inches and length nearly 32 inches. Suitable means are provided for sealing the cylinder, which holds the liquid, with a mild steel disk. The new model shell, after having been charged, is placed in the borehole in the coal. The borehole is tamped with incombustible stemming in a manner similar to that employed with permissible explosives. The liquid carbon dioxide within the cylinder is gasified by means of a heating element, which is immersed centrally within the liquid. This element consists of a combustible mixture of powdered solids with an electric squid embedded therein. Wires which extend from the shell to the outside of the borehole are connected by leading wires to a single-shot permissible blasting unit. The squid is ignited by operating the blasting unit; this in turn ignites the combustible mixture of the heater unit. The temperature of the liquid carbon dioxide is raised above its critical temperature so that it is changed into a gas. This change causes a very rapid increase in pressure of the gas within the shell that causes the steel disc to be sheared. The gasified carbon dioxide expands and rushes through the aperture in the borehole that causes a rupture of its walls, thus bringing down the coal. J. H. G.

The Nature and Source of Plant Nitrogen. J. L. JODIDI. *J. Frank. Inst.*, **208,** 767–71 (Dec., 1929).—Why is it, that although plants take up nitrogen from the soil as ammonia and nitrates, their tissues contain but minute traces of these compounds? How is this change brought about in the plants? The reason is that plants, especially the higher ones, are synthesists par excellence. It must be admitted that the plant has as yet outdone the chemist in the way of synthesis. The organic nitrogenous substances synthesized from the two simple inorganic substances, the author arranges schematically as follows: Nitrates → Nitrites → Ammonia → Nuclein bases → Purin derivatives → Nucleic acids → Nucleins → Nucleoproteins. Ammonia → Monoamino acids → Hydroxyamino acids → Diamino acids → acid amides → Polypeptides → Peptones → Proteoses → Proteins → Alkaloids.

It is evident that proteins are associated with life functions in the plant organism, and that they are the most important integral constituent of the protoplasm. The author reviews the sources of atmospheric nitrogen at length. The significance of each of the complex nitrogenous compounds is discussed. The lecithins and phosphatides are known to have nutritive value about equivalent to the fats. Of overwhelming interest, however, is the conclusion of Prof. V. Grafe of Vienna, based upon his researches, that the phosphatides must be considered as the mother substances of the vitamins, the dietary essentials of which have been found to be absolutely necessary for maintenance, growth, and reproduction. J. H. G.

The Probable Use and Effect of Chemical Agents in Future Warfare. J. E. ARDREY. *Chem. Warfare*, **15,** 633–6 (Oct. 15, 1929).—The author questions whether it is possible to prevent the use of toxic chemical agents in future wars. "Chemical warfare is today the most scientific method of conducting war and represents the latest development of the military art." Its importance is realized by all of the great powers, and study, research, and funds are being devoted to its development. "As long as war constitutes the last ratio among nations, we must take into account the chemical means, because the military history of all times and of all nations does not show a single instance in which an arm or a new tactic, having once brought success, has ever been abandoned afterwards." E. R. W.

Group Protection of the Civilian Population against War Chemicals. F. A. HENNEY. *Chem. Warfare*, **15,** 641–7 (Oct. 15, 1929).—In the next war chemicals will be used where they will be most effective in reducing the armed resistance of an opponent. No portion of a nation will be entirely safe from a chemical attack carried on by means of airplanes. The danger will of course be greatest near large industrial centers. "The average person is known to possess a perverted idea of the effect of war chemicals. This condition probably is an outgrowth of the intensive propaganda inaugurated by the Allies during the World War to turn world opinion against the Germans who first used war chemicals. Whatever the source, the root must be extracted by careful instruction in protective measures to be used against chemicals. The magnitude of this educational program is so extensive that a peacetime course of instruction in methods of group protection against chemicals should be given in the public schools." E. R. W.

We Must Be Prepared against War Gas as an Extremity. C. G. RIGGS. *Chem. Warfare*, **15,** 637–41 (Oct. 15, 1921).—In order to combat the spreading of poison chemicals over large areas by the use of thousands of airplanes revolutionary modification of present military tactics will be necessary. Chemical warfare was a success in the World War, we cannot depend upon treaties to prevent its use in future wars. The best assurance for our continued peace will be to let other nations know that we are prepared in a superior manner to conduct a ruthless chemical campaign as well as to protect ourselves against their chemical attacks. We must be prepared to use, and to fight, war gas as an extremity. E. R. W.

SCIENTIFIC REVIEWS AND BIBLIOGRAPHIES

X-Ray Metallography in 1929. G. L. CLARK. *Metals & Alloys*, **1,** 14–7, 57–68, 98–111, 153–61, 206–21 (July through Nov., 1929).—A complete discussion of the nature of X-rays as applied to metallography both in theory and practice is given. The technic for preparation of radiographic pictures is discussed. The interference phenomena of X-rays in a crystal may be used to determine the space group of that crystal. With the growing mass of information concerning the structure of matter, a rational systematization of chemistry should result. The following are types of information which may be obtained from X-ray diffraction data: (*a*) crystalline or non-crystalline; (*b*) crystallographic system, space group, unit cell dimensions, parameters of atoms or molecules; (*c*) deduction of crystal unit (atom, ion, molecule), of

size of unit, of type of binding, and of general properties of solid to be expected; (*d*) chemical identity, chemical and crystallographic changes and stability; (*e*) allotropic modifications; (*f*) type and mechanism of alloy formation; (*g*) single crystal or aggregate; (*h*) crystallographic orientation of single crystal or of grains in aggregate; (*i*) random or fibered aggregate and relative degree in intermediate stages; (*j*) grain size in an aggregate (particularly in colloidal range); (*k*) internal strain or distortion; (*l*) extent of deformation and mechanism of fabrication in rolling, drawing, etc.; (*m*) analysis of effect of heat treatment, grain growth, control and mechanism of recrystallization, and the establishment of scientifically correct annealing technic; (*n*) differentiation between surface and interior structure.

A detailed discussion of each of these topics is given. Original references are included in this comprehensive survey. R. L. H.

The Vegetable Tannins. K. FREUDENBERG. *Nature*, **124,** 697–9 (Nov. 2, 1929).—This is a lecture delivered before Section B (Chemistry) of the British Association at Cape Town on July 26, 1929. It is a simple and interesting account of the nature of tannins as glucosides of the gallic acids; with references to the masterly work of Emil Fischer. The relation of the tannins to quercetin and other catechin derivatives is discussed. F. B. D.

Instruments and Methods Used for Measuring Spectral Light Intensities by Photography. G. R. HARRISON. *J. Optical Soc. Am.*, **19,** 267–316 (Nov., 1929).—The advantages of the photographic method are: (1) the emulsion acts as a recording medium, giving a permanent fixed response to a large number of simultaneously incident intensities, (2) it acts as an integrating medium, summing up the total energy falling on it at a particular spot, (3) it furnishes the sensitivity not available in the photoelectric cell or thermopile. The apparatus necessary, the methods used, and results are given with a comprehensive bibliography.

The outline given herewith of this summary indicates the content:

I. The General Principles of Photographic Photometry: (1) *Characteristics of Photographic Emulsions*—(*a*) the characteristic curve, (*b*) variation of the characteristic curve with type of emulsion, (*c*) variation of emulsion characteristics with wave length; (2) *Photometry*—(*a*) homochromatic spectrophotometry, (*b*) heterochromatic spectrophotometry.

II. General Apparatus and Methods: (1) *Spectrographic Outfits*—(*a*) the spectrograph, (*b*) grating mountings, (*c*) illumination of spectrograph slit, (*d*) plate holders and cassettes; (2) *Timing of Exposures;* (3) *Sources of Light for Calibration;* (4) *Methods of Varying Intensity for Producing Calibration Curves*—(*a*) neutral methods, (*b*) selective methods; (5) *Standard Sources*—(*a*) continuous sources, (*b*) line sources, (*c*) corrections for dispersion and line breadth; (6) *Development*—(*a*) developers, (*b*) the Eberhard effect, (*c*) treatment after development, (*d*) the "brush effect;" (7) *Densitometers and Microphotometers*—(*a*) general, (*b*) thermoelectric microphotometers, (*c*) photoelectric microphotometers, (*d*) microphotometers of other types, (*e*) the microphotometry of spectrum plates.

III. Special Methods of Photographic Photometry: (1) *Methods for Calibrating with a Single Exposure*—(*a*) general, (*b*) step weakeners, (*c*) the wedge method, (*d*) intensity distribution from coarse gratings, (*e*) line intensity distribution; (2) *Limiting Density Methods*—(*a*) the outline wedge method, (*b*) the coarse grating method; (3) *Methods Primarily for Use in Absorption or Reflection Measurements (Special Homochromatic Methods)*—(*a*) the higher sector photometer, (*b*) Lewis' sector photometer, (*c*) Jones' method, (*d*) other methods.

IV. Special Spectral Regions: (*1*) *the infra-red*, (*2*) *the visible*, (*3*) *the ultraviolet*, (*4*) *the Schumann region*, (*5*) *the X-ray region.* R. L. H.

Rubber Bibliography. *India Rubber World*, **81,** 75 (Nov., 1929).—Recent important articles. C. W. E.

HISTORICAL AND BIOGRAPHICAL

Autobiographical Notes. MARIE CURIE. "Pierre Curie," The Macmillan Co., New York City, **1926,** pp. 155–242. M. W. G.

Madame Curie and Radium. B. HARROW. "Eminent Chemists of Our Time," D. Van Nostrand Co., Inc., New York City, 2nd edition, **1927,** pp. 155–76. M. W. G.

Madame Curie: Her Work. B. HARROW. "Eminent Chemists of Our Time," D. Van Nostrand Co., Inc., New York City, 2nd edition, **1927,** pp. 389–402. M. W. G.

Presentation of the Gibbs Medal to Mme. Curie. *Chem. & Met. Eng.*, **24,** 1132–40 (1921). M. W. G.

Madame Pierre Curie and Her Work. B. SZILARD. *Chem.-Ztg.*, **35**, 1361–2 (1911).—Nobel prize winner in chemistry in 1911. M. W. G.

Le Radium. Célébration du vingt-cinquième anniversaire de sa découverte (1898–1923). Les Presses Universitaires de France, **1923.** M. W. G.

Sir Humphry Davy. B. HARROW. *Sci. Mo.*, **29**, 447–50 (Nov., 1929).—A brief story of the life of Sir Humphry Davy, recounting his contributions to the properties of nitrous oxide, to the application of electricity to chemistry and to his work with the halogens and the halogen acids. Davy is described as a genius in the laboratory, a rapid worker but not always painstaking, quick in execution and sometimes hasty in deduction. Most of his researches were completed before he was thirty-four years old. G. W. S.

Thomas A. Edison—Chemist. *Laboratory*, **2**, no. 5, 67–8 (1929).—A short account of Mr. Edison's early chemical investigations with a picture of his Menlo Park Laboratory, recently restored at Dearborn, Michigan. H. H. K.

In Memory of a Forgotten Inventor: Gobel and Incandescent Lamps. *Giorn. chim. ind. applicata*, **11**, 467–8 (Oct. 1929).—While in the United States the celebration of the 50th anniversary of the Edison incandescent lamp was commencing, the Association of German Electrotechnicians on September 14th held a ceremony at Springe, near Hanover, in memory of Enrico Gobel and placed a tablet on the house in which he was born. As was proved beyond doubt in the courts of Boston following a suit for a patent and as has been officially recognized, Gobel was the first to prepare incandescent lamps with carbon filaments, free of air, and to openly reveal his invention. As early as 1855, 24 years before Edison, Gobel, who had emigrated to New York, used in his business place such lamps of his own manufacture, the threads of which were made of carbonized bamboo fibers.

Gobel died suddenly after the end of the trial which recognized his priority. M. A. C.

August Friedrich Horstmann. *Nature*, **124**, 732 (Nov. 9, 1929).—"Professor August Friedrich Horstmann, a pioneer in the field of physical chemistry, whose investigations of the thermodynamics of chemical processes are well known, died recently in Heidelberg at eighty-seven years of age. We are indebted to the *Chemiker-Zeitung* for the following details of his career. Born at Mannheim in 1842, Horstmann studied under Bunsen and Kirchhoff at Heidelberg, where he was appointed extraordinary professor in 1872 and honorary professor in 1889. He conducted numerous researches upon dissociation, vapor-pressure, combustion, chemical equilibria, and solutions, but for very many years his active participation in scientific research was prevented by almost complete blindness. His thermodynamical studies of chemical processes were published in Ostwald's 'Klassiker der Naturwissenschaft,' edited by Professor van't Hoff." F. B. D.

The Centenary of Kekulé's Birth. *Giorn. chim. ind. applicata*, **11**, 468 (Oct., 1929).—The German Chemical Society celebrated at Bonn on September 6th the centenary of the birth of August von Kekulé. Many participated in the meeting, including a number of former pupils of the great master.

Dr. H. Wieland, of Munich, gave the commemorative address. He spoke at length of the life and work of Kekulé, who, born in 1829 at Darmstadt, continued his studies at Giessen under Liebig, received his doctorate at Heidelberg under Bunsen, and was called in 1858 to Ghent, which he left in 1867 to succeed A. W. Hofmann in the chair of chemistry of the University of Bonn. Here he remained until his death in 1896. The other speakers dwelt on the influence exerted on the development of chemistry by Kekulé's theory of the structure and formula of benzene, which he established in 1865.

Dr. Anschutz, who succeeded Kekulé in the chair at Bonn after his death, presented to the society the two-volume biography of August von Kekulé of which he is the author. M. A. C.

Prof. W. H. Perkin, Jr. H. E. ARMSTRONG. *Nature*, **124**, 623–7 (Oct. 19, 1929).—An account of the life and work of W. H. Perkin, Jr., with many references to his father, by one of the few men who knew them both intimately

Perkin, born June 17, 1860, was educated at the City of London School and the Royal College of Science and then spent five years at Würtzburg with Wislicenus and at Munich with Baeyer. Returning to England, he was instructor for a year at the Owens College in Manchester and then from 1886 to 1912 professor of chemistry at the Heriot-Watt College in Edinburgh. In 1912 he was appointed to the chemistry chair at Oxford, successor to Odling. A man of many talents and interests, he was, with the exception of Willstätter, possibly the greatest of "synthetic" chemists of today, as shown by his long list of beautiful papers.

Armstrong says, "Of all our chemists he has been the most human, the most inspiring in his absolute adoration of the laboratory and its effable art—an art fully disclosed only to the few—an art insufficiently encouraged and practiced today; yet the art upon which alone industry and progress are founded." F. B. D.

Louis Nicolas Vauquelin. *Nature*, **124,** 733 (Nov. 9, 1929).—"On November 15 occurs the centenary of the death of the French chemist, Louis Nicolas Vauquelin, whose name is associated with the discovery of chromium and beryllium, two of the twenty-eight elements discovered during the eighteenth century. Though less well known than his great contemporaries, Guyton de Morveau, Berthollet, Lavoisier, Fourcroy, and Chaptal, Vauquelin attained a distinguished position among French chemists and held many important positions. His principal work, however, was done in his laboratory, where he carried out a very large number of analyses. The discovery of chromium was made in 1797, that of beryllium, formerly called glucinum, in 1798. Vauquelin was the son of a farm laborer in the village of Saint-André-des Berteaux, where he was born on May 16, 1763, and his boyhood was one of hardship. At the age of fourteen he found employment with a chemist at Rouen from whence he went to Paris, where, after suffering illness and destitution, he was befriended by a pharmacist named Cheradame, who later on introduced him to Fourcroy, whose assistant, collaborator, and friend Vauquelin became. Altogether, Vauquelin was partly or solely responsible for some three to four hundred scientific papers, mostly devoted to analyses. In a short review of his work, Sir Edward Thorpe said, 'He described a method of separating the platinum metals, and worked upon iridium and osmium. He investigated the hyposulfites, cyanates, and malates. He discovered the presence of benzoic acid in the urine of animals; with Robiquet he first isolated asparagin; with Buniva, allantoic acid; and with Bouillon de la Grange, camphoric acid.' Vauquelin died in his native district at the Chateau des Berteaux." F. B. D.

The Seventieth Birthday of Rudolf Wegscheider. *Chem.-Ztg.*, **80,** 777 (Oct. 5, 1929).—On Oct. 8, 1929, Rudolf Wegscheider celebrated his 70th birthday. He is now Ordinarius of General and Physical Chemistry at the University of Vienna where he had studied and was appointed professor in 1899. His first interests were in organic chemistry, which field he never left even when he became interested in physical chemistry. His numerous publications deal with the theoretical problems of organic chemistry. About 35 articles deal with the saponification of unsymmetrical di- and tribasic acids. He studied the saponification of glycerides, the theory of ester formation from alcohol and acid in the presence and absence of hydrogen chloride, the saponification by alkalies, and similar problems. When he was appointed assistant to Landolt in 1884, he became interested also in physical chemistry. From then on he began to publish articles on chemical kinetics, the behavior of strong electrolytes, the theory of indicators, the decomposition of ammonium nitrate, the vapor pressure of ammonium chloride, photochemical kinetics, thermodynamics, and many others. Wegscheider is largely responsible for the modern laboratory which was added to the University of Vienna in 1921. He is an excellent scientist with profound knowledge and great productivity. He has been honored many times by various scientific societies and institutions. L. S.

Richard Zsigmondy. P. A. THIESSEN. *Chem.-Ztg.*, **88,** 849–56 (Nov. 2, 1929).—Only a few years ago (1925) Zsigmondy was given the Nobel prize in chemistry and the years since were darkened by sickness. In 1898, he published his classic work on the colloidal dispersion of gold in water. He had discovered a method of preparing gold dispersions with reproducible properties. This was the basis for a large number of fundamental experiments which led to the proof for the metallic nature of gold in these preparations, to the electrical charge on these particles, the coagulation by salts, the impossibility of redissolving the precipitates, the examination of Cassius' gold purple, etc. He proved that mixtures of colloids may have the appearance of compounds. Together with H. Siedentopf from the Zeisswerke in Jena, he built the so-called ultramicroscope with the aid of which it is now possible to detect gold particles of a diameter of a four-millionth mm. He also did a large amount of work on gels and ultrafiltration. His book "Kolloidchemie" is a classic in his field.

Richard Zsigmondy was born in Vienna on April 1, 1865. Already as a boy he became interested in the subject of chemistry which he later studied at the Polytechnic Institute of Vienna and afterward at the University of Munich. In 1889 the young doctor of philosophy became an assistant to Prof. Kundt in Berlin. In 1893 he was called to the Polytechnic Institute of Graz and in 1897 to the glass concern Schott und Gen. in Jena as scientific consultor. In 1903 he went to the University of Göttingen as head of the Institute for Inorganic Chemistry where he remained until his death.

Zsigmondy was admired by his students as a scientist and beloved by them as a man. His research work will keep his name in the memory of mankind and his teaching will keep his name in the heart of his students. L. S.

The Centennial Celebration of the Chemische Centralblatt. R. WILLSTÄTTER. *Z. angew. Chem.*, **42**, 1049–52 (Nov. 9, 1929).—The first copy of the *Pharmaceutisches Centralblatt* was edited in 1830 by G. Th. Fechner and published by Leopold Voss in Leipzig. In the preface Fechner promised to the reader the quick and complete communication of all facts important and interesting to the pharmacist. At that time there were hardly any chemists in Germany and there was no essential difference between pharmacy and chemistry. The first bi-weekly periodical was soon published every week and grew rapidly with the science. Twenty years after its foundation its name was changed to *Chemisch-Pharmaceutisches Centralbaltt* and six years later to *Chemisches Centralblatt*. The editors were: Gustav Theodor Fechner (1830–1834), Christian Albert Weinlig (1835–1844), Richard Buchheim (1845–1847), J. A. L. Wilhelm Knopp (1848–1862), Rudolf Arendt (1862–1902), Albert Hesse (1902–1923), Maximilian Pflücke and Ernst Behrle (1923–1928), Maximilian Pflücke (1928–19—). Arendt developed the periodical to a complete repertorium of pure and applied chemistry; Hesse stressed the technical part and the patent references; Pflücke and Behrle built up the index on the formula system. In 1899, the Deutsche Chemische Gesellschaft assumed responsibility for the periodical. Since the World War the journal was aided by the Adolf Baeyer Gesellschaft for the promotion of chemical literature.

The hundred volumes of the *Chemisches Centralblatt* picture the international development of chemistry. They show the tremendous progress where each man stands on the shoulders of his predecessor and lifts his student on his own. They show the dawn of organic chemistry; they give the first radicals; from the formulas of methane and benzene, the structural world of the organic chemical world is built up; aniline and phenol rise from coal tar; the foundations are laid for the quantity production of the chemical industry. The analyses begin to extend to carbohydrates, proteins, chlorophyll, hormones, and vitamins; the gems of nature are synthesized; new elements are discovered and the periodic table is created. Physical chemistry builds the bridge between physics and chemistry. A new era commences with the discovery of radium.

Numerous facts are summarized in the references of the periodical and the formulas and constants hide the troubles, suffering, and joy of the men who discovered them. The masters of chemistry appear: Berzelius, Faraday, Mitscherlich, Bunsen, Schönbein, Pasteur, Liebig, and Wöhler; Berthelot, Kekulé, Griess, Hoffmann; Mendeléeff and L. Meyer, Baeyer and E. Fischer, V. Meyer, Curtius, Lord Raleigh, P. Curie, Moissan, van't Hoff, Werner, Arrhenius, and many others.

The growth of scientific production can be seen from the following comparison whereby it must be remembered that the references have been shortened, the print made smaller, and the pages larger:

YEAR	REFERENCES	PAGES	INDEX
1830	403	544	40 pp.
1897	5,689 (including 846 patents)	2,464	138 pp.
1928	36,424 (including 12631 patents)	5,920	1,031 pp.
1929 (1st half)		3,501	

The author suggests that the periodical should be divided into several sections and that it should be made possible to subscribe separately to these sections. He explains that very few physicians subscribe to the journal but that many doctors would be interested in a section "Biochemistry." He also recommends that the abstract journals in all the countries could coöperate and thus minimize the amount of work to be done. L. S.

EDUCATIONAL MEASUREMENTS AND DATA

Relation between Mental and Physical Status of Children. EDIT. *School*, **41**, 162–3 (Nov. 7, 1929).—School children in two counties in Illinois were examined physically by medical officers of the United States Public Health Service and were given mental tests by the trained personnel of the Illinois State Institute for Juvenile Research. These examinations were entirely independent of each other.

All children making low scores on the group-mental tests were given individual tests. The intelligence quotient resulting from these mental tests was found to have a considerable correlation with indications of school progress such as school reports, grades repeated or skipped, and teachers' estimate. This quotient was used in considering the relation of the mental and physical status of the children.

It was found that the average number of physical defects decreased as the intelligence quotient increased. This relationship, however, appears to be of a general rather than of a specific nature. This may mean that the physical defects slowed down mental development or that mental deficiency and physical defects go hand in hand from inheritance. B. C. H.

Recognition of Individual Differences. G. H. RYAN. *High Sch. Teacher*, **5**, 297–9 (Nov., 1929).—The arrangement of individuals in order of intelligence as determined by an intelligence test does not afford a view of human differentiation which is really very useful. As the tests are made more and more specific the rating by the general intelligence test is seen to be but a part of the story. A close personal study of the individual cases is, at present, about the only certain method of approaching the problem. A great aid to this end is a school organized as a comprehensive and well-regulated community. The application of analyses of phases of the problem, as made by other students, is found to be profitable to all concerned. B. C. H.

The Benefits of Homogeneous Grouping. V. P. SKINNER. *High Sch. Teacher*, **5**, 305–6 (Nov., 1929).—Homogeneous grouping may be: (1) ability grouping, (2) performance grouping, (3) interest grouping, or (4) grouping for remedial work.

Such grouping may be achieved by: (1) teachers' estimates, (2) achievement tests, (3) mental age and I. Qs., (4) other available data.

Advantages of homogeneous grouping may be listed as: (1) lower per cent of failures, (2) less wasted teacher effort, (3) interest and attention more easily obtained, (4) possibly broader course for faster students, (5) drill and stress on minimum essentials for slow groups, (6) even slow students may, by assignments tempered to their abilities, be led to develop habits of success.

Difficulties in the way of such grouping are: (1) child is "sentenced," cataloged by a single test, (2) the grading of different groups is not comparable, (3) lack of pupil leadership in slow group, (4) slow section "teacher killers."

In one high school a trial of such a plan of segregation resulted in a vote of thirty to one, of the teachers who had used it, in its favor. B. C. H.

THE PHILOSOPHY OF EDUCATION

Interpreting Education Anew. N. D. SHOWALTER. *Wash. Educ. J.*, **9**, 70 (NOV., 1929).—Supt. Showalter proposes the following objectives: (1) To make education conform to the fundamental needs of childhood and youth. (2) To interpret education in the light of practical demands made upon the citizenship of our time. (3) To shape public school organization and plan courses and curricula in such manner as to stimulate success and not failure in the pupil. (4) To remeasure the school in the light of its adaptation to the child, and not expect the child to merely conform to the abstract requirements of daily routine. (5) To make the instruction sufficiently flexible to meet the needs of the different capacities of individual children. He also suggests several aims for consideration. A. E. C.

The Scope and Sphere of a University. G. J. LAING. *Bull. Am. Assoc. of Univ. Profs.*, **15**, 468–75 (Oct., 1929).—The legitimate application of the term "University" to an institution connects two ideas: a higher form of learning such as is closely associated with research work, and a range of activity that covers at least a fair number of the recognized fields of study: arts, science, law, etc. There is both a qualitative and a quantitative element in the word's significance.

From the qualitative point of view, the Junior College has no place in a university, It is a part of the secondary school process and should be treated accordingly. This is necessary in order to save the standards of the university; conserve the professor's energies in teaching for university students; and to prevent the immaturity of junior college students from being a factor in the social life of the university.

The type of teaching should be modified by the reduction of the number of informational courses; an increase of courses requiring constructive independent work of the student; greater student liberty so far as class attendance is concerned; abolition of course examinations; increased number of informal courses and publication of all Ph.D. theses. B. C. H.

THE PHILOSOPHY OF SCIENCE

Modern Concepts in Physics and Their Relation to Chemistry. I. LANGMUIR. *Science*, **70**, 385 (Oct. 25, 1929).—President's address delivered before the 78th meeting of the A. C. S., Minneapolis, Minn., September 11, 1929. [See *J. Am. Chem. Soc.*, **51**, 2847–68 (Oct., 1929).] G. H. W.

Preaching the Gospel of Science. R. C. BENEDICT. *Science*, **70**, 368 (Oct. 18, 1929).—"Readers of *science* are accustomed to have their attention focused mainly on exploratory work, investigation, as the most important means by which the advancement of science may be furthered." "It is the purpose of this communication, however, to ask consideration for a different point of view: *viz.*, the problem of the broad diffusion of the facts of scientific discovery, old and new, and of the inculcation of habits of scientific thinking as a problem coördinate in importance with research." "Diffusion of science, both content and method, can best be promoted through the multitudes of pupils in the secondary schools of the country. High-school teachers of science are the best agents for this diffusion."

An estimate of the public reached by high-school teachers of New York and of the country at large and a detailed study of the personnel of the New York high-school scientific faculty are given. G. H. W.

Changing Ideas in Research. V. KELLOGG. *Outlook*, **153**, 343 (Oct. 30, 1929).—Research is a much used word. It refers to profound and exact work in the natural sciences by such men as Michelson, Millikan, and Compton, and to necessarily less exact work by students of the social sciences. "It is used to describe the feverish activities of the large and rapidly increasing number of workers in various fields of industrial science." "Finally it is used to give dignity and an air of scientific exactitude to all sorts of compilations and summarizing of data....by men and women of all degrees of competency and incompetency." A great deal of valuable research is going on in universities and industrial laboratories. The difference between pure research and applied research is more hypothetical than actual. Applied science rests on pure science. The United States is not neglecting either but as measured by Nobel prize winners it is behind England and Holland. G. H. W.

PROFESSIONAL

Should Professors' Salaries Be Higher? T. ARNETT. *Bull. Am. Assoc. Univ. Profs.*, **15**, 436–8 (Oct., 1929).—Through a questionnaire sent out by the General Education Board it has been found that out of 11,361 college teachers 66.5 per cent supplement their regular salaries for the nine months' session by other earnings. Of the married teachers, 77.2 per cent supplement their regular earnings. The amount so added was 23.8 per cent of their regular salaries. These extra earnings aggregate 15 per cent of the total salaries of all reporting.

Of the teachers thus earning extra income, 71.9 per cent said that they did this extra work from necessity and 77.2 per cent said they would prefer to do only the regular work.

The author suggests: (1) some outstanding salaries which might stimulate the ambitious, (2) that uniform salaries tend to make for a low salary schedule, (3) an increase of the total salary schedule by at least 15 per cent, and (4) to control and regulate outside income-bearing activities. He raises the question: "May not permanent tenure have operated to keep salaries down?" B. C. H.

Research Professorships. A. O. LEUSCHNER. *Bull. Am. Assoc. Univ. Profs.*, **15**, 440–4 (Oct., 1929).—The author feels that it would be inadvisable to have that title used in connection with teachers who do more research than others of the teaching staff. The reason is; it might lead to the inference that all faculty members not so designated were to do teaching work exclusively. He holds that all teachers of college offerings should do some research for a teacher may be "trained *by* research as well as trained *for* it."

Some flippant characterizations of Research Professorships include: exemption from teaching; large sums of money to expend for equipment for such work; a large salary "like the dean's;" an admission that universities are just awaking to the importance of research and "only a new form of advertising."

From investigations made, it appears that such a title is not very common among universities and that it is becoming less so. Special endowments might obligate an institution to list the beneficiaries from such endowments as "Research Professors" but such exceptional practice does not commit the institution to it as a policy.

It is more important that the teaching professors be permitted a schedule that makes possible research work as well as the teaching than that some few members of the faculty be designated by the title Research Professor because their major activities are research. B. C. H.

CONTEMPORARY NEWS AND COMMENTS IN CHEMISTRY AND EDUCATION

Dedication of the Chemistry Building at Princeton University. W. FOSTER. *Sci. Mo.*, **29**, 478–80 (Nov., 1929).—In conjunction with the dedication ceremonies there

was held an international conference on catalysis and the mechanism of chemical reaction. Representatives from England, France, and Germany spoke. [*Editor's Note:* See THIS JOURNAL, **6**, 2080–103 (Dec., 1929).] G. W. S.

The Centennial Celebration of the Chemische Centralblatt. *See same title under* **Historical and Biographical,** page 464.

Current Metallurgical Research at the Bureau of Standards. H. S. RAWDON. *Metals & Alloys*, **1**, 144–52 (Oct., 1929).—Account is given of work of advisory committee and scope of information work. Among the recently completed projects are flow in low-carbon steels at elevated temperatures, blistering during the enameling of cast iron, accelerated laboratory corrosion test methods for zinc-coated iron, surface cooling of steels when quenched in various media, wear resistance and mechanical properties of railroad bearing bronzes at different temperatures, steel for case hardening normal and abnormal steels. A discussion is given on special equipment of the work carried on at the present time on bearing bronze, steel castings, bismuth, lead-base babbitts, etc. Several illustrations, diagrams, and graphs are included. R. L. H.

A Nation's Tribute to Men of Science. *Laboratory*, **2**, no. 5, 73–6 (1929).—Address delivered by Herbert Hoover at the celebration of the fiftieth anniversary of Thomas A. Edison's invention of the incandescent lamp. H. H. K.

Training Chemical Engineers at N. C. State College. E. E. RANDOLPH. *Chem. & Met. Eng.*, **36**, 684 (Nov., 1929).—In 1925 chemical engineering was officially established at North Carolina State College and became one of the major departments of the college. At this time 22 students were enrolled. This year there were 23 candidates for degrees. The curriculum contains all the fundamental engineering courses and a liberal portion of humanist subjects combined with specific training in chemical engineering. There has been a demand for graduate engineers and in recent years all have been employed before graduation. Two fellowships have been established by large chemical industries. In training chemical engineers at N. C. State College, three important factors are considered—personality, character, and technical training. R. L. H.

FOREIGN CHEMICAL AND EDUCATIONAL CONDITIONS

Technical Education in Yorkshire. ANON. *Chem. Age*, **21**, 285–7 (Sept. 28, 1929).—An outline of the work in chemistry and related sciences offered by Bradford Technical College, Huddersfield Technical College, and the Leeds University. E. R. W.

GENERAL

What It Costs to Keep Clean. R. MILLAR. *American*, **108**, 50–2 (Nov., 1929).—Ten cents of every dollar you spend goes for cleanliness. Keeping clean is more expensive than clothes, education, amusements, or owning a car. The first item on this bill is soap, which amounts at a conservative figure to four dollars per year per member of the family. Polishes, cleaning powders, and disinfectants increase the outlay by another four dollars per year per family member. Among the tools of cleanliness are listed vacuum cleaners, washing machines, and electric irons and add over thirty dollars per year to the cost and that figure does not include the less pretentious brooms and floor mops. On the defensive side of cleanliness are to be cataloged aprons, towels, table cloths, napkins, sheets, pillow cases, and bedspreads.

The shrine of cleanliness of a home is undoubtedly the bathroom. Here are housed such adjuncts of cleanliness as salves, lotions, creams, atomizers, and perfumery. The male member of the household usually has about this room the necessary equipment for his own facial care, shaving equipment. Likewise here is the usual depository for toothbrushes and their accessories.

When carefully reckoned the hot water costs of the bathroom are a rather surprising item of fourteen dollars, more or less, per year per member of the family.

Totaling, the annual cost for a family of four aggregates almost five hundred dollars per year. This cares for what might be termed "personal and household cleanliness." To this should be added labor costs, estimated for housewife, laundress, auto cleaning, etc., about five hundred dollars; civic cleanliness such as street cleaning, garbage collection, water supply, paint, etc., about seventy-five dollars. Thus the grand total is brought up to approximately one thousand dollars per year. B. C. H.

Local Activities

Purpose and Organization

The purpose of the Local Activities Section of the JOURNAL OF CHEMICAL EDUCATION is briefly but clearly stated in its title. Any items of local news from institutions, A. C. S. Sections, Teachers' Associations, or other organizations which are of such a nature as to make them of more than purely local interest rightfully belong to this Section.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It is desirable to have a representative appointed to report news regularly. Suitable material sent to the editorial office before the 20th of each month will be published in the following month's journal. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the following suggestions are followed, however, the necessity for such action will be largely obviated.

Material to Be Reported

1. Notices of local scholarships or fellowships and announcements of new or unusual courses in chemical education or special fields of chemistry.
2. Reports of dedication of new science buildings, stressing the unique features.
3. News notes concerning activities of prominent scientists and educators and of the honors and awards made to them.
4. Promotions within, or changes of, personnel of a department.
5. Notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.
6. Accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations. Where original or unusual features are included, it is desirable that they be described in some detail.
7. Any subscriber to the JOURNAL, desiring new teaching position or seeking eligible candidate for teaching vacancy, is entitled to two free announcements yearly in this column.

American Chemical Society. WILLIAM MCPHERSON, dean of the Graduate School of Ohio State University, became president of the A. C. S. on January 1st as a result of the society's annual election. Dean McPherson will serve during 1930, succeeding DR. IRVING LANGMUIR, associate director of research of the General Electric Company.

MOSES GOMBERG, professor of chemistry in the University of Michigan, was chosen president for 1931. In accordance with a recent change in its constitution, the society now elects each year a president and a president-elect, who serve in successive years.

PROF. JAMES F. NORRIS, of Massachusetts Institute of Technology, and CHARLES L. REESE, of E. I. du Pont de Nemours & Company, Wilmington, Del., were elected directors for 1930–32.

The following councilors-at-large were named: EDWARD BARTOW, professor of chemistry, Iowa State University; PROF. S. C. LIND, Director of the School of Chemistry, University of Minnesota; HUGH S. TAYLOR, professor of physical chemistry, Princeton University; DAVID WESSON, consultant, Montclair, N. J.

Prof. McPherson was born in Xenia, Ohio, July 2, 1864. From Ohio State he received the degree of bachelor of science in 1887, and the master's degree in 1890. He took the Ph.D. at the University of Chicago in 1899. Ohio State conferred upon him the degree of doctor of science in 1895.

Prof. McPherson has been a member of the Ohio State chemistry faculty since 1892, rising to a full professorship in 1897, and to the headship of the Graduate School in 1911. He was acting president of the University in 1924.

He was a lieutenant-colonel in the Chemical Warfare Service during 1918–19, and was advisor to the Trench Warfare Section of the Ordnance Department. He is a Fellow of the American Association for the Advancement of Science, and a member of the Deutsche Chemische Gesellschaft. He is the author of numerous textbooks on chemistry, and an extensive contributor to scientific publications.

Prof. Gomberg was born in Elizabetgrad, Russia, in 1866. He was educated at the Elizabetgrad Gymnasium—at the University of Michigan, from which he

received the degree of B.S. in 1890, M.S. in 1892, and Sc.D. in 1894. Later he studied in the Universities of Munich and Heidelberg.

He has been a member of the teaching staff of the University of Michigan since 1893, and a professor since 1904. He has also been connected with the U. S. Bureau of Mines. In 1914 he was awarded the Nichols Medal of the American Chemical Society, of which he is a member. He is a Fellow of the American Association for the Advancement of Science, and holds a membership in the National Academy of Science.

Prof. Gomberg received the Chandler Medal from Columbia University in 1927.

Chandler Medal. The Chandler Medal (1929) for achievement in science has been awarded by Columbia University to DR. IRVING LANGMUIR, president of the American Chemical Society, and associate director of the Research Laboratory of the General Electric Company.

Dr. Langmuir received the medal at a national gathering of scientists in Havemeyer Hall, Columbia, at 8.15 P.M. on December 13th, when he delivered the annual Chandler Lecture on "Electrochemical Interactions of Tungsten, Thorium, Caesium, and Oxygen."

The medal, an outstanding distinction in chemistry, was established in 1910 by friends of the late PROF. CHARLES FREDERICK CHANDLER, pioneer in industrial chemistry, and a founder of the American Chemical Society, with a gift which constitutes the Chandler Foundation.

Previous medalists have been LEO H. BAEKELAND, W. F. HILLEBRAND, W. R. WHITNEY, F. GOWLAND HOPKINS, EDGAR F. SMITH, ROBERT E. SWAIN, E. C. KENDALL, S. W. PARR, MOSES GOMBERG, and J. ARTHUR WILSON.

This is the second medal to be bestowed upon Dr. Langmuir during the present year by Columbia, where he was graduated in 1903 with the degree of metallurgical engineer. At the last commencement Dr. Langmuir received the Class of 1889 Medal, awarded every three years to a graduate of the School of Engineering or of the School of Architecture who shall have distinguished himself in any sphere of human effort.

After his graduation from Columbia, Dr. Langmuir studied at the University of Göttingen, where he received the degree of Ph.D. The honorary degree of doctor of science was conferred upon him by Northwestern University in 1921, by Union in 1923, and by Columbia in 1924. The University of Edinburgh made him a doctor of laws in 1921. He has twice been awarded the Nichols Medal of the New York Section of the American Chemical Society. He has also received the Rumford, Hughes, and Perkin Medals.

Dr. Langmuir is a member of many scientific societies. Since 1909 he has been connected with the General Electric Research Laboratory at Schenectady, N. Y.

Brown University. During the first part of December, DR. CHARLES A. KRAUS made a trip to the Middle West. He addressed the Minnesota Section of the A. C. S. and represented Brown University at the dedication of the George Herbert Jones Chemical Laboratory at the University of Chicago. On this occasion he gave an address on recent and future developments in inorganic chemistry.

MR. ONSAGER participated in a symposium on electrolytes held at Yale University on December 13th.

DR. CHAMBERS and DR. WOOSTER attended the Organic Symposium held at Princeton University during December.

DR. G. R. COWGILL, of Yale University, addressed the Rhode Island Section of the A. C. S. in the auditorium of the Jesse Metcalf Chemical Laboratory on December 13th. He spoke on the rôle of vitamins and other rare chemicals in adequate nutrition.

DR. VICTOR K. LAMER, of Columbia University, addressed the Rhode Island Section on December 10th. His topic was "Solutions of Electrolytes."

The first meeting of the year of the Brown Chapter of Sigma Xi was held under the auspices of the chemistry department on December 20th. Supper was served at 6 P.M. in Rogers Hall, after which there were several talks by members of the staff. DR. W. A. NOYES, JR., spoke on "Some Aspects of Solid Decompositions," and DR. N. W. RAKESTRAW on "Chemistry in the Field of Oceanography."

College of the City of New York. PROFESSOR L. J. CURTMAN and DR. LEO LEHRMAN contributed an article entitled "The Preparation and Standardization of Ammonium Polysulfide and Its Action on Some Group 2 Sulfides," to the December issue of the JOURNAL OF CHEMICAL EDUCATION.

DR. S. BRADFORD STONE, of the Brooklyn Center, has been made assistant editor of *Rheology*, a new journal devoted to the study of phenomena connected with the flow of matter. Dr. Stone has been interested in viscosity for a number of years and has published a number of papers in that field of physical chemistry.

DR. L. C. PAN, instructor in electroplating, gave a special lecture on December 5th on the subject of "Chromium Plating" before the New York Section of the Electrotypers Union. The lecture was supplemented by demonstration of preparing the chromium electrolyte and depositing chromium metal on copper and nickel electrotypes.

Columbia University. PROFESSOR V. K. LA MER addressed the Rhode Island Section of the A. C. S. on January 10th, on the subject of solutions of electrolytes.

Dickinson College. DR. HARRISON E. HOWE, editor of *Industrial & Engineering Chemistry*, addressed the Mohler Scientific Society in Carlisle on December 11th, 1929. His subject was "Chemistry, the Creator of Industries." After the lecture Dr. Howe inspected the Dickinson College Priestley Collection.

The Franklin Institute. According to the December 14th issue of *School and Society*, a series of Christmas lectures for young people was given by DR. HARRY N. HOLMES, professor of chemistry in Oberlin College, under the auspices of the Franklin Institute, Philadelphia, on December 26th, 27th, and 28th. The title of the series was "It Is a Colloidal World after All." The titles of the three lectures were as follows: "It's the Little Things That Count," "Oil and Water Do Not Mix—But Wonderful Emulsions Are Possible," and "Jellies and Gels." There was a remarkably large attendance at all three of these lectures.

Indiana University. The Indiana chapter of Phi Lambda Upsilon Fraternity plans to present to the department of chemistry a bronze plaque, upon which the name of the junior student who has the highest average in the department will be placed each year.

The Indiana Section of the A. C. S. has announced that it will award a membership in the American Chemical Society to the senior who has the highest scholastic standing at the end of the first semester of his senior year. This award is to be given every third year to a student of Indiana University. At other times, it will be awarded to senior students in other Indiana colleges and universities.

The plans for the new chemistry building at Indiana are now nearing completion. It is expected that actual construction will begin early in the spring.

Iowa State College. The meetings of the chemistry section of the A. A. A. S. included a symposium on the teaching of chemistry. DR. NEIL E. GORDON, of The Johns Hopkins University, Editor of THIS JOURNAL, presided. Papers were read by chemistry teachers in the high school, junior college, agricultural college, and university fields.

A meeting of the Ames Section of the A. C. S. was held November 13th. DR. R. H. FERGUSON, formerly of Ohio

State University, but now of Procter and Gamble, Cincinnati, delivered a very interesting lecture on "The Phase Rule Viewpoint in Industry." The first part of the lecture consisted of a brief description of the soap industry and some of its historical superstitions, and the second part dealt with the application of the phase rule in the production of soap.

After four years of organization, aided by the efforts of the members of the Alpha Chi Sigma fraternity on the staff of the college, the Chemists Club of Iowa State College has been granted a charter in Alpha Chi Sigma. The officers of the new chapter are: H. O. SMITH, president; P. C. BIRD, vice-president; JAMES FRANKEN, secretary; PAUL BRUINS, treasurer; R. M. BOWIE, reporter; H. P. GUEST, ritualist; R. L. FOSTER, historian.

DR. NORMAN A. CLARK gave an interesting talk on his trip abroad at the November meeting of the Osborn Club. Some of the places he visited were Edinburgh, St. Andrews, Paris, Switzerland, and London. A large portion of his time was spent in visiting the schools and colleges.

DR. F. E. BROWN was elected vice president of the Physics-Chemistry Section of the Iowa State Teachers' Association.

PROFESSOR W. F. COOVER gave a talk on the utilization of agricultural wastes before the Science Teachers' Association of the Iowa State Teachers' Association.

DR. G. E. CUNNINGHAM, of the Rice Institute, Houston, Texas, is now in the ceramics department of Iowa State College, directing research on physical chemistry as applied to ceramics.

DR. O. R. SWEENEY visited Purdue University on November 7th and addressed the local section of the A. C. S. on the "Utilization of Agricultural Wastes." Dr. Sweeney has made frequent trips to Dubuque in connection with the organization of the Maize Board Plant there.

Mellon Institute of Industrial Research. Each year since 1925 Mellon Institute of Industrial Research has been giving a series of radio talks, broadcast from the University of Pittsburgh Studio of the Westinghouse Electric & Manufacturing Company's Station KDKA. Each of the five series presented so far has been published in booklet form; three of these publications are really textbooks of home economics, and, in fact, are being widely used in domestic science courses.

In order to supplement these series of talks, Mellon Institute has decided to schedule eight radio discourses on "Science in the Kitchen" during 1930. These talks will be delivered on the Fridays of February and March, at 5.45 P.M., from the University of Pittsburgh Studio of Station KDKA and will subsequently be published by the University. In general, the new series will relate to the selection, care, and service of foods, and each talk will be given by a research specialist of the Institute.

The complete program is as follows: February 7th, "The Well-Planned Kitchen," DR. GEO. D. BEAL; February 14th, "The Intelligent Purchasing of Foods," DR. W. W. DUECKER; February 21st, "The Care of Food in the Home," DR. E. W. MORRISON; February 28th, "Good Proportions of Foods," DR. G. J. COX; March 7th, "The Uses of Milk in the Home," DR. L. W. BASS; March 14th, "Good Meals by the Young Homemaker," MR. E. R. HARDING; March 21st, "Food for Young Children," DR. R. N. WENZEL; March 28th, "School Lunches," DR. R. F. BEARD.

Middlebury College. RALPH STERLING TEMPLE (Ph.B., Rutgers, 1929) and HOMER W. J. CRESSMAN (B.S., Muhlenberg, 1929) have been appointed graduate fellows in chemistry.

DR. STERLING N. TEMPLE, of Roessler and Hasslacher Chemical Corporation, addressed a joint meeting of the Vermont Section of the A. C. S. and The Alchemists (a local chemistry club) on the evening of

December 13th. His subject was "Some Phases of Industrial Research."

Missouri School of Mines and Metallurgy. "Cosmic Rays" was the title of a lecture given at the Missouri School of Mines and Metallurgy, November 25th, by DR. ROBERT ANDREWS MILLIKAN, chairman of the board and director of the Norman Bridge Laboratory for Physics of the California Institute of Technology, recipient of numerous medals and honorary degrees, and 1923 Nobel prize winner in physics for his measurement of the charge of an electron and investigations in the ultra-violet.

Dr. Millikan presented the evidence as to the formation of these rays in interplanetary space during the formation there of helium, nitrogen, oxygen, and silicon from elementary hydrogen.

The Ohio State University. The new $250,000 building which is to house the College of Pharmacy and the Department of Bacteriology is rapidly nearing the roofing stage. For a number of years the College of Pharmacy has had quarters in the chemistry building. According to present plans the new building will be ready for occupancy for the next academic year.

PROFESSOR W. L. EVANS, of the department of chemistry, represented the department and also the University at the dedicatory exercises of The George Herbert Jones Laboratory for graduate and research work in chemistry of the University of Chicago on December 16th and 17th.

MR. W. C. HAMMOND, formerly of The United States Gypsum Company, completed all the requirements for the Ph.D. degree in chemical engineering in the autumn quarter. For the remainder of the year he will devote his entire time to teaching and also to his own personal commercial industry in the reclaiming of plaster of paris.

Recently DR. W. C. FERNELIUS, of the department of chemistry, addressed the students and scientific faculty of Ohio Northern University on his work dealing with the ammonia system of chemistry.

DR. J. E. DAY, of the department of chemistry, delivered a popular talk on "The Manufacture and Uses of Liquid Air" to the employees of the Ohio Bell Telephone Company.

The Board of Education of the State of Ohio is operating a School of the Air. The entire staff of the department of chemistry has been included in the chemical program of this school. The broadcasting is being relayed from the University Station through station WLW at Cincinnati. The speakers and radio talks given thus far are as follows: W. E. HENDERSON, "Early Chemists;" J. E. DAY, "What Chemistry Is and What the Chemist Does;" W. L. EVANS, "The Element Oxygen" and "The Element Hydrogen," C. W. FOULK, "The Compound Called Water;" and H. V. MOYER, "The Mixture Called the Atmosphere." The program will be continued by other members of the department during the months of January, February, March, and April.

The Pennsylvania State College. The Fourth Annual Priestley Lectures were given this year by DR. LOUIS NAVIAS, ceramist of the General Electric Company, Schenectady, New York. Dr. Navias discussed the relation between physical chemistry and ceramics in a series of five lectures in the chemistry amphitheater, December 16th–20th. The following is a brief resumé of the topics covered: A survey of the field of ceramics showing by numerous examples the dependence of ceramics upon physico-chemical principles; The vitreous state—glasses, glazes, and enamels; The properties of some important natural materials such as silica minerals, clays, and feldspars; Porcelain and similar bodies; Shaping refractory oxides and the artificial production of sapphires.

On the evening of November 22nd, DR. VICTOR K. LAMER, professor of physical

chemistry, Columbia University, addressed the Central Pennsylvania Section of the A. C. S. on the subject "Strong Electrolytes and Reaction Velocity." Dr. LaMer discussed various aspects of the Debye theory and pointed out the way in which it explains the anomalous behavior of strong electrolytes.

During the week of November 18th, MRS. PAULINE BEERY MACK, who is in charge of textile chemistry at The Pennsylvania State College, and MRS. NELLIE MYRES ROBERTS, holder of the textile standardization fellowship of the American Home Economics Association, worked in the textile laboratories at the Bureau of Standards running physical tests on silk pieces. Mrs. Roberts is continuing the work of WINIFRED FORBES, holder of the textile standardization fellowship of last year, who worked at The Pennsylvania State College on the effect of weighting on silk.

The results of Mrs. Roberts' researches will feature in the Federal Trade Commission hearing on weighted silk which will probably be held next September. The American Home Economics Association is coöperating with the Silk Association of America, the National Retail Dry Goods Association, and other interested groups in studying the complicated silk weighting problem, in an effort to find a way of curbing the tendency to overweight silks.

Princeton University. At chemical colloquia held during recent months, the following papers were read and discussed: "Complex Naphthalenes," MR. ROBERT SPENCE (October 29th); "Stereochemistry of the Oximes," DR. EVERETT S. WALLIS (November 12th); "The Luminous Oxidation of Phosphorus," DR. H. J. EMELEUS (November 26th); "Structure of the Diazohydrates," MR. A. B. BOESE, JR. (December 3rd); and "Conduction in Metals I," PROFESSOR T. J. WEBB (December 11th). These meetings were well attended by faculty members, research workers, and graduate assistants of the department.

The Chemical Club held two meetings during the past fall. On November 13th, DR. W. F. G. SWANN, director of the Bartol Research Foundation, spoke on "Atomic Phenomena in Wave Mechanics," while at the meeting on December 6th, DEAN GERALD WENDT, of Pennsylvania State College, spoke on "Molecular Rearrangements."

State University of Iowa. DR. J. C. MORRELL, of the Universal Oil Products Co., of Chicago, Illinois, addressed the Iowa Section of the A. C. S. on Dec. 6th, on the subject, "The Cracking Process, a Universal Source of Motor Fuels."

PROF. JACK HINMAN, of the Sanitation Division, addressed the Ames Section of the A. C. S. on November 25th on the subject "Water as a Manufactured Product."

Tufts College. New appointments in the chemistry department of Tufts College are as follows:

ALBERT Q. BUTLER, A.B., Wesleyan University, 1923; A.M. 1924; Harvard Graduate School, 1924, instructor in chemistry. Mr. Butler has been appointed instructor in quantitative analysis at the Harvard Summer School for 1930.

J. CHESTER LITTLEFIELD, B.S., Boston University, 1922; M.S., Princeton University, 1924; instructor, North Carolina College for Women 1928–29; instructor in chemistry.

ARTHUR W. PHILLIPS, B.S., Tufts College, 1915; M.S., Harvard University, 1921; instructor, Massachusetts Agricultural College 1924–27; instructor in chemistry.

DR. CHARLES F. H. ALLEN, formerly instructor in chemistry in this department, is now assistant professor at McGill University.

DR. REUBEN B. ELLESTAD has been appointed to the University of Minnesota for special study in the analysis of rocks under the general supervision of PROFESSOR GROUT.

The student chemical society has made a provisional schedule of eight meetings

for the coming year. The schedule includes trips, speakers, and coöperation with the other engineering societies in the running of the engineering dance.

From last year's graduating class E. T. CASELLINI is employed in the chemical research laboratory of the Hygrade Lamp Company, Salem, Mass.

R. V. ELMS is chemist at the Dry Ice Company, New York City.

Union College. The intersectional meeting of the Western New York, Cornell, Rochester, Syracuse, and Eastern New York Sections of the A. C. S. was held at Schenectady, New York, December 6 and 7, 1929.

The morning of December 6th was devoted to registration and inspection trips through the General Electric Company's research laboratory and plant, after which luncheon was served by the Company. The afternoon meeting was held in the colloquium room of the research laboratory. The chairman, DR. C. B. HURD, of Union College, presided. Papers were presented as follows: "Wave Mechanics and Its Application to Valency," DR. SAUL DUSHMAN, General Electric Co.; "Some Problems of X-Ray Analysis of Organic Crystals," DR. W. P. JESSE, General Electric Co.; "Preliminary X-Ray Studies of the Peroxides," DR. A. J. KING, Syracuse University; "The Ultra-Violet Absorption Spectra of Some Pyrones and Pyroxonium Salts," E. C. HUGHES, Cornell University.

On Friday evening, December 6th, a banquet was given at the Mohawk Golf Club. An opera, "La Rosa Irlandais de L'Abie," written and directed by ARTHUR J. SHERBURNE of the General Electric Company and given by local talent, was presented. An address was given by DR. IRVING LANGMUIR on adsorbed films on metals and the application of the results obtained to the explanation of simple electrochemical reactions.

On Saturday morning, December 7th, a symposium on Chemical Education was held at Union College, presided over by the chairman, PROFESSOR R. A. BAKER of Syracuse University. The sections were welcomed to Union College by DEAN EDWARD ELLERY. The following papers were presented: "Laboratory Equipment and Laboratory Instruction," DR. G. A. HILL, Wesleyan University; "Lectures and Lecture Experiments," DR. A. W. DAVISON, Rensselaer Polytechnic Institute; and "Experiences in Teaching Industrial Chemistry," DR. T. A. WILSON, Union College. The meeting adjourned at 11.00 A.M. to attend a colloquium at the research laboratory of the General Electric Company. DR. A. L. MARSHALL, of the Company, spoke on "Reactions with Excited Mercury Atoms."

The committee in charge of the program was composed of the officers of the Eastern New York Section, together with DR. A. KNUDSEN, Albany Medical College, and DR. H. S. VAN KLOOSTER, Rensselaer Polytechnic Institute.

University of Chicago. PROFESSOR W. D. HARKINS gave two lectures at the University of Illinois on December 10th. The first of these, given before the chemistry department, was on "Surfaces and Their Structures," and the second, on "Atom Building," was given before the University of Illinois Section of the A. C. S.

On December 11th, DR. M. S. KHARASCH gave an address before the St. Joseph Valley Section of the A. C. S. at South Bend, Indiana.

DR. MARY M. RISING gave an address at a luncheon on December 28th at a joint meeting of the women members of the American Association for the Advancement of Science and members of the Ames Section of the A. C. S. on the topic of "Chemistry in Medicine."

VICTOR SULIT has been elected a full member of the Society of Sigma Xi; N. J. ANDERSON and W. O. WALKER have been made associate members.

CHARLES NEIL CAMERON, Ph.D., 1923, assistant professor of chemistry, University of Saskatchewan, died recently.

DR. C. H. MILLIGAN, Ph.D., 1919, has resigned from the Champion Coated Paper Company, Hamilton, Ohio, and accepted an appointment as research chemist for the American Agricultural Chemical Company, Newark, New Jersey.

University of Cincinnati. A second series of radio talks will be given on Wednesday evenings (7 P.M., E. S. T.) over station WLW by SAUL B. ARENSON, assistant professor of chemical engineering, College of Engineering and Commerce, University of Cincinnati, on "Taking the Mist Out of Chemistry." The program is as follows: January 22nd: "The Manufacture of Soap." January 29th: "Technology of Sugar Making." February 5th: "Glass from Sand." February 12th: "Chemical Research in Industry."

A meeting of the Cincinnati Section of the A. C. S. was held at the university on December 11th. (*See* **Cincinnati Section, A. C. S.**)

University of Denver. Much more experimental data is necessary to throw desired light upon the nature and origin of the cosmic rays. The experiments of HESS and KOHLHORSTER and those of MILLIKAN and CAMERON have given much information on the nature of these penetrating radiations but more information is desirable. Experiments are to be conducted in at least two continents simultaneously to determine whether there is a directive effect. This work will be under the direction of DR. A. H. COMPTON of the University of Chicago, who will make observations at Chicago under varying conditions. DR. BENADE will make observations in the Himalayas and DR. J. C. STEARNS, of the University of Denver, will carry on the experiments in the Rocky Mountains. Modifications of the ionization chamber and electroscope are planned which will yield greater accuracy and sensitivity than has been attained in previous experiments.

University of Florida. The twenty-fourth meeting of the Florida Section of the A. C. S. was held in the new chemistry building of the University of Florida, Gainesville. A smoker was held in conjunction with the regular meeting with the members of Delta Epsilon premedical fraternity as guests of the Section. The program was as follows: "The Preparation of Pure Hydrocarbons and Their Reactions with Nitrosyl Chloride," DR. P. A. FOOTE, College of Pharmacy, University of Florida; "Citrus By-Products," DR. L. W. GADDUM, biochemist, U. S. Experiment Station, Gainesville, Florida.

The officers for the coming year are: *chairman*, DR. V. T. JACKSON, professor of chemistry, University of Florida; *vice-chairman*, DR. L. J. LEWIS, head, department of chemistry, Florida State College for Women, Tallahassee; *secretary-treasurer*, DR. R. C. GOODWIN, department of chemistry, University of Florida; *councilor*, DR. W. H. BEISLER, department of chemistry, University of Florida.

DR. T. R. LEIGH and PROFESSOR A. P. BLACK attended the fifth biennial convention of Gamma Sigma Epsilon Chemical Fraternity, held in Columbia, S. C., November 29th–30th. Dr. Leigh was re-elected worthy grand alchemist of the fraternity and Professor Black was elected grand recorder and editor of *The Ray*, the fraternity magazine.

DEAN TOWNES R. LEIGH, of the College of Pharmacy, University of Florida, has been appointed dean of a committee of five, selected by the American Association of Colleges of Pharmacy to consider the establishment of a uniform curriculum for the colleges of pharmacy of the United States. The findings of this committee will be presented to the Association at its meeting in Baltimore next May, at which time at least one day will be devoted to its discussion.

Dr. Leigh has associated with him on this committee other educators as follows: DR. JULIUS A. KOCH, dean of the Pittsburgh College of Pharmacy; DR. EDWARD A. KRAUS, dean of the University of Michigan College of Pharmacy,

DR. RUFUS A. LYMAN, dean of the University of Nebraska College of Pharmacy; and DR. H. C. BIDDLE, dean of the College of Pharmacy of the University of California.

The appointment of Dr. Leigh as chairman of this committee, comes in recognition of his leadership in the development of the College of Pharmacy of the University of Florida.

University of Mississippi. The Chemistry Club of the University of Mississippi, in conjunction with the industrial class, is showing a scientific movie once a week, using from three to six reels each evening. Students and faculty members may attend.

University of Notre Dame. The monthly meeting of the St. Joseph Valley Section of the A. C. S. was held in Chemistry Hall on November 20th. The topic, "Principles and Methods of Glass Blowing," was interestingly handled by MESSRS. RASCHER and BETZOLD, of the Rascher and Betzold Chemicals and Chemical Apparatus Supply Company, Chicago.

Mr. Rascher discussed types of glass that must be used and procedures that must be followed in the preparation of high-grade glassware and precision instruments. Mr. Betzold, who is an expert glass worker, illustrated his talk on methods by actually preparing a thermometer and several other articles.

So many wished to attend this meeting that it became necessary to hold an afternoon meeting to accommodate Notre Dame students. Messrs. Rascher and Betzold agreed and spoke to a crowded house at each session.

PROFESSOR M. S. KHARASCH, of the University of Chicago, addressed the Section on "The Trend of Modern Concepts in Organic Chemistry." He began his address by sketching the development of the structural formulas concept, pointing out the tremendous value of this idea to past developments in organic chemistry as well as possible values for the future.

Dr. Kharasch stressed the importance of a knowledge of thermodynamics and photochemistry to the organic chemist. He also discussed the electron concept of valence as applied to organic compounds. This is a field in which Dr. Kharasch is especially interested and in which he has done considerable work.

FR. NEUWLAND and DR. MAHIN, of the department of chemistry, attended the forty-fifth annual meeting of the Indiana Academy of Science held in Richmond, Indiana, December 5th to 7th. They read papers before the chemistry and bacteriology sections.

University of Pennsylvania. The 1928 group of the University of Pennsylvania Chapter of the Alpha Chi Sigma Fraternity have placed in the hallway of the Harrison Laboratory of Chemistry a decorative bronze plaque, on which is to be inscribed the name of the outstanding senior in chemistry or chemical engineering. In determining this, scholarship, personality, and campus activities are to be taken into consideration.

University of Pittsburgh. PROFESSOR ALEXANDER SILVERMAN, head of the chemistry department, addressed the Cleveland Section of the A. C. S. on Thursday, December 12th. His subject was "Some Recent Developments in Glass Manufacture."

University of the City of New York. At the meeting of the Science Forum of the New York Electrical Society on Wednesday, December 11, 1929, DR. W. C. MACTAVISH, professor of chemistry at Washington Square College, New York University, spoke on "The Magic of Modern Chemistry."

University of Southern California. Founded a half century ago, in 1880, The University of Southern California is preparing to commemorate its fiftieth birthday by a Semi-Centennial Celebration in June, 1930. This anniversary

celebration, which will occupy a week, is under the direction of DEAN ROCKWELL D. HUNT, appointed general chairman by PRESIDENT R. B. VON KLEINSMID.

Eleven veteran educators who have been affiliated with the University of Southern California for 25 years or more comprise an honorary faculty committee of the Semi-Centennial Celebration.

Educational exhibits, scientific studies, faculty publications, and departmental demonstrations will be among the academic features of the program.

With addresses by national notables prominent in an appropriate field, four new buildings will be dedicated with fitting ceremonies.

The Alumni Association will be in charge of the Golden Jubilee Banquet, as well as numerous class reunions; and it is planned that the cornerstone of a new library building, to be erected by alumni contributions, will be laid during the Semi-Centennial Week.

A definite program of future expansion involving the investment of $40,000,000 has been planned, providing for more ample endowments and additional structures to house more adequately the colleges of commerce and music, the schools of religion and education, a separate building to contain the school of speech and a university theater, a marine laboratory, and other divisions.

University of Virginia. DR. DONALD H. ANDREWS, of the Johns Hopkins University, was the principal speaker in the November series of lectures before the department and graduate school of chemistry at the University of Virginia. His subject was "Energy Distribution and the Force of Valence in Organic Molecules." The Raman effect was discussed as a means of getting fundamental frequencies of the particles taking part in molecular vibration, from which conclusions may be drawn correlating the frequencies with specific heat data.

Growing interest in chemical engineering as a field of applied science, possessing greater utility today than ever before, is reflected in the recent organization of the Chemical Engineering Society by the students enrolled in that course. FRANK W. ROSE, JR., of Washington, D. C., was elected *president;* G. V. MOORE, Buchanan, Va., *vice president;* R. W. QUARLES, Richmond, Va., *secretary;* W. K. PRICE, JR., New Market, Va., *treasurer;* and H. S. DUNHAM, Saltville, Va., *corresponding secretary.* The enrolment includes students attending the school in eleven states extending from New Hampshire to Alabama. One of the important contributions of such an organization to the education of the students is its ability to bring engineers of national prominence before the group and acquaint the students with the problems to be faced in their future professional careers.

Sioux Valley Chemistry Club. The following is the program of a meeting of the Sioux Valley Chemistry Club held in Vermilion, South Dakota, on December 14, 1929: "Some Recent Developments in Food and Drug Control," GUY G. FRARY, state chemist, Vermilion, South Dakota; "Methods and Results of Experiments on Chemotherapy of Bird Malaria," DR. EDWIN H. SHAW, professor of biochemistry, University of South Dakota, Vermilion, South Dakota; "Some Unusual and Striking Lecture Experiments in General Chemistry," PROF. A. L. HAINES, professor of inorganic chemistry, University of South Dakota, Vermilion, South Dakota.

South Dakota Education Association Science Section. The South Dakota Science Section of the S. D. E. A. met at Rapid City from November 25th to 27th, inclusive. The program presented was as follows: *Theme:* Adequate Science Preparation and Sequence. "Uses of Chemistry," ANDREW KARSTEN, Rapid City; "The Aims and Present Status of Physics Teaching in Our Teachers' Colleges," J. B. STORDAHL, Spearfish; "Types of Objective Test Items in Chemistry,"

ROBERT O. DOTT, Pierre; "The Mathematical Requirements for Chemistry and Physics, Namely Direct and Inverse Proportion," C. J. MENDENHALL, Lead; "College Freshmen in Chemistry," GERALD G. OSTERHOF, Rapid City; "The Mathematical Viewpoint for the Study of the Natural Sciences," A. M. PARDEE, Vermilion; "Individual Research Problems for High-School Students," ARTHUR W. SCHMIDT and C. J. MENDENHALL, Lead; "The Activities of the Division of Chemical Education," J. H. JENSEN, Aberdeen; "Chemistry for Fun," RALPH E. DUNBAR, Mitchell; "Uses and Manufacture of Cement," WM. A. ERNST, Rapid City.

The group met for a business luncheon at the Alex. Johnson Hotel on Tuesday noon, November 26th. Industrial excursions were made the last day of the session to the plants of the South Dakota State Cement Plant, Warren-Lamb Lumber Company's Mills, as well as the museum of the South Dakota State School of Mines. This feature of the program was under the direction of DR. CARL G. WATSON, president, of Rapid City.

Officers elected for next year include: ROBERT O. DOTT, Pierre, *president;* RALPH E. DUNBAR, Mitchell, *secretary-treasurer;* E. R. PRUNTY, Rapid City, and A. L. HAINES, Vermilion, members of the Executive Committee.

Vassar College. According to the December 20, 1929, issue of *Science*, a series of lectures was given at Vassar College during the week of November 18th–23rd, with the following program: PROFESSOR ROGER ADAMS, of the University of Illinois, "Synthetic Organic Acids as Substitutes for Chaulmoogra Oil;" DR. HARRISON E. HOWE, editor of *Industrial and Engineering Chemistry*, "Chemistry in the New Competition;" DR. FLORENCE R. SABIN, of the Rockefeller Institute for Medical Research, "Biological Effects of Different Chemical Fractions Isolated from the Tubercle Bacillus;" PROFESSOR HUGH S. TAYLOR, of Princeton University, "Speed and Sloth in Chemical Reactions" and PROFESSOR HENRY C. SHERMAN, of Columbia University, "Chemistry."

Wesleyan University. PROFESSOR C. R. HOOVER has been reëlected a councilor of the Connecticut Valley Section of the A. C. S.

DR. G. ALBERT HILL presented a paper on "Laboratory Equipment and Laboratory Instruction" at the Intersectional Meeting at Schenectady on December 7th. On December 10th he gave an address in Middletown on "The Utilization of Some Agricultural Wastes."

Ames Section, A. C. S. *See* **Iowa State College.**

Cincinnati Section, A. C. S. The 310th meeting of the Cincinnati Section of the A. C. S. was held in the auditorium of the chemistry building of the University of Cincinnati on Wednesday, December 11, 1929, at 8.00 P.M.

DR. ANSON HAYES, director of metallurgical research for The American Rolling Mill Company at Middletown, Ohio, spoke on "Some Results of Statistical Studies in Corrosion." Prior to his association with this company, Dr. Hayes was for twelve years professor of physical chemistry at Iowa State College. He taught graduate courses in thermodynamics and directed research work in a study of factors which influence the stability of iron carbide, particularly in white iron composition suitable for the manufacture of malleable iron. While associated with PROFESSOR W. D. HARKINS at the University of Chicago, Dr. Hayes performed fundamental scientific research in the successful separation of chlorine into its isotopes.

Eastern New York Section, A. C. S. The newly elected officers of the Eastern New York Section are: *president*, DR. C. B. HURD, Union College; *vice president*, ARTHUR J. SHERBURNE; *secretary*, ROY

H. KIENLE; *treasurer*, B. W. NORDLANDER. The last three officers are associated with the General Electric Company.

Florida Section, A. C. S. *See* **University of Florida.**

Indiana Section, A. C. S. *See* **Indiana University.**

Iowa Section, A. C. S. *See* **State University of Iowa.**

Maryland Section, A. C. S. The 121st meeting of the Maryland Section of the A. C. S. was held on Friday, November 22nd at Remsen Hall, The Johns Hopkins University, Baltimore, Maryland. PROFESSOR MAX BODENSTEIN, who is director of the Friedrich Wilhelm Institute, University of Berlin, and was James Speyer Visiting Professor of Chemistry at Johns Hopkins, addressed the section on "The Chemical Actions of Light."

The 122nd meeting of the Maryland Section was held on December 6th at Remsen Hall, The Johns Hopkins University. The speaker, PROFESSOR GEORGE L. CLARK, of the University of Illinois, chose as his subject, "New Applications of X-Ray Research in Chemistry and Industry."

Northeastern Section, A. C. S. The 240th meeting of the Northeastern Section of the A. C. S. was held on December 13, 1929, at The American Academy of Arts and Sciences. PROFESSOR W. ALBERT NOYES, JR., spoke on "The Effects of Radiation on Chemical Systems."

Rhode Island Section, A. C. S. *See* **Brown University** and **Columbia University.**

St. Joseph Valley Section, A. C. S. *See* **University of Notre Dame.**

University of Illinois Section, A. C. S. On Monday evening, November 25th, the University of Illinois Section of the A. C. S. had as its guest and speaker, DEAN W. M. BLANCHARD, of DePauw University. He spoke on the place of the college and university in chemical education.

University of Missouri Section, A. C. S. In response to the suggestion of the Division of Chemical Education of the National Society, the Local Section sponsored the following program in connection with Arts and Science week:

"Some Observations Concerning Student Disabilities in the Study of General Chemistry," by PROFESSOR W. J. BRAY, chairman, department of chemistry, Missouri State Teachers College, Kirksville, Mo.

"Twenty Years of Experimenting in the Teaching of College Chemistry," by DR. HERMAN SCHLUNDT, chairman, department of chemistry, University of Missouri.

DR. W. W. CARPENTER, School of Education, University of Missouri, acted as leader of the discussion.

On November 19th, DR. FERGUSON, chemist for the Procter & Gamble Company, gave two talks before the University of Missouri Section upon the "Chemistry of Soap Making."

On December 16th, the University of Missouri Section held its yearly meeting in the form of a farewell dinner to DR. and MRS. RICHARD BRADFIELD, who are leaving this month for Columbus, Ohio, Dr. Bradfield having accepted a position at Ohio State University. After the dinner, the election of officers for this Section of the Chemical Society for the coming year took place. The officers are as follows: *president*, DR. ALLEN STEARN; *vice-president*, DR. ADDISON GULICK; *secretary*, DR. GERALD F. BRECKENRIDGE; *treasurer*, DR. M. V. DOVER; *Councilor*, DR. HERMAN SCHLUNDT.

Vermont Section, A. C. S. *See* **Middlebury College.**

Illinois Association of Chemistry Teachers. At the meeting of the Illinois Asso-

ciation of Chemistry Teachers on November 22nd at the University of Illinois, the following officers were elected: *president*, W. E. HARNISH, 303 Education Bldg., Urbana, Illinois; *vice-president*, DORR M. SIMER, High School, Decatur, Illinois; *secretary-treasurer*, S. ALETA MCEVOY, High School, Rockford, Illinois; *senator representing colleges*, DR. JOHN C. HESSLER, Knox College, Galesburg, Illinois; *contributing editor of Journal of Chemical Education*, DR. B. S. HOPKINS, Urbana, Illinois.

The Illinois Association of Chemistry Teachers again is offering a prize to the high-school student who presents the best exhibit at the spring meeting.

A report of the committee on "Methods of Teaching" was given by the chairman, MABEL SPENCER, of Granite City.

A report of the committee on "Tests" was given by W. A. HARNISH, of Urbana.

It was decided to have a February meeting of the Illinois Association of Chemistry Teachers to discuss further projects that are being carried on by the Association.

New England Association of Chemistry Teachers. The 119th meeting of the N. E. A. C. T. was held at Simmons College, Boston, Massachusetts, on December 14, 1929. The morning program included a trip through the plant of the United Drug Co., 43 Leon St., Boston, Massachusetts, and luncheon at Simmons College Lunch Room. At the afternoon session the following papers were presented: MR. GEORGE C. FROLICK, general sales manager of the United Drug Co., "The Awakening of a Chemical Consciousness of the Buying Public as Far as Their Medicine Requirements Are Concerned;" MISS INA M. GRANARA, "A Cultural Course in Chemistry for Women;" DR. HERMAN C. LYTHGOE, director, Division of Food and Drugs, Massachusetts Department of Public Health, "Experiences in Food Law Enforcement."

Washington State Association of Chemistry Teachers. The following officers were elected at the October meeting of the Washington State Association of Chemistry Teachers: *president*, H. E. GAINES, Olympia High School, Olympia, Washington; *vice president*, LAURA ANGST, Mt. Vernon, Washington; *secretary-treasurer*, V. L. CLARK, Stadium High School, Tacoma, Washington; *senators*, MISS GRETCHEN KAUFMAN, DR. ZAHLIA JENKS GAILEY, and MR. F. A. RANTZ.

J. T. Baker Chemical Company Analytical Chemistry Fellowship. Through the generosity of the J. T. Baker Chemical Company, Phillipsburg, New Jersey, the Eastern Fellowship in analytical chemistry will be available for the academic year 1930–31, for study in any institution conferring the doctor's degree in chemistry in the New England States, New York, Pennsylvania, New Jersey, Delaware, and Maryland.

The Fellowship will be granted to an advanced student in analytical chemistry and the stipend is $1000 annually. The candidate must possess the bachelor's degree or its equivalent, and a broad training in the fundamental branches of chemistry.

Applications for the coming year should be made before February 15th to any member of the committee and should include the following information: (*a*) age; (*b*) degrees; (*c*) previous training in chemistry; (*d*) outline of proposed problem; (*e*) name of the person under whose direction the work is to be done. It is understood that the applicant will ascertain the requirements of the institution where the work is to be done. Consideration of the application will be facilitated if five copies are sent. Further information may be secured from the Committee: PROFESSOR GREGORY P. BAXTER, Harvard University; PROFESSOR PHILIP E. BROWNING, Yale University, *Secretary;* PROFESSOR E. M. CHAMOT, Cornell University; PROFESSOR H. A. FALES, Columbia University; PROFESSOR N. H. FURMAN, Princeton University, *Chairman*.

Southern California Section, A. C. S. From 1923 to the present time, in the student contest sponsored by the Southern California Section of the A. C. S., the award is the annual possession of a silver loving cup, which will eventually be presented permanently to the school winning it oftenest in ten years.

A committee of three persons is appointed each year to conduct the contest, according to the rules of the section. They have full jurisdiction under these rules. The examination is written and is limited to first-year chemistry students, who may take any one of the possible forms. Sometimes one central place is chosen for all contestants and sometimes examinations are held at several places simultaneously under the supervision of duly appointed persons. These examinations are on questions prepared anew each year by the committee.

The trophy is awarded for the ensuing year to the team making the highest score. Teams are made up in accordance with a schedule which considers the size of the school and only bona fide first-year chemistry students are eligible. In addition, prizes are awarded to the three individuals who stand highest in the contest.

The presentation of the awards takes place at an annual meeting in June. The successful team and its teacher, as well as the winning students, are guests at dinner. After the presentation, responses are made by the various recipients.

Mellon Institute of Industrial Research, University of Pittsburgh. DR. GEORGE D. BEAL, assistant director, Mellon Institute of Industrial Research, addressed the Lehigh Valley Section of the A. C. S. on November 14th. He spoke on the topic "Some Contributions Which Science Is Making to Industry."

DR. LAWRENCE W. BASS, executive assistant, Mellon Institute of Industrial Research, spoke before the Northern West Virginia Section of the A. C. S. on November 22nd on the subject "Economic Effects of Industrial Research."

New York Chapter, American Institute of Chemists. At the meeting of the New York Chapter of the American Institute of Chemists on December 13, 1929, DR. NEIL E. GORDON, The Johns Hopkins University, spoke on "Education of Chemists."

Tenth Annual Ohio State Educational Conference. "Reaching the Individual" will be the keynote of the Tenth Annual Ohio State Educational Conference to be held in Columbus, April 3, 4, 5, 1930. DR. ROBERT M. HUTCHINS, president of the University of Chicago, will speak at the Thursday night general session. MR. E. H. SOTHERN, well-known actor and dramatic reader, will give a series of readings from Shakespeare on Friday night.

More than one hundred speakers, including some thirty-five from out of the state, will participate in this educational conference in which a registration of over 5000 is expected. Last year 5100 were registered.

Asphalt Tanks Explode. Two asphalt tanks at the Destrehan plant of the Mexican Petroleum Corporation near the mouth of the Mississippi River recently exploded. Property damage was estimated, unofficially, at between $14,000 and $15,000. Steam and foam were used to check fire in the tanks following the blasts, the blaze being extinguished in half an hour.

F. W. Grey, superintendent in charge of the Destrehan plant, said he has dealt with asphalt twenty years with no previous instance of explosion, apparently without exterior cause, having come within his experience. One tank was full, the other empty. The blasts were a few seconds apart, the first explosion being in the empty tanks, according to information gathered by company officials.—*Oil, Paint and Drug Reporter*

Recent Books

An Introduction to Modern Organic Chemistry. L. A. COLES, B.Sc. (Lond.), A. I. C. Senior Chemistry Master, Batley Grammar School. Longmans, Green and Co., 1929, New York. xv + 452 pp. 13.5 × 19 cm. Figures 78, portraits 10. $2.50.

This new elementary book on organic chemistry presents the subject in a somewhat different manner from that usually found. It is a text and manual combined and includes the details for 107 laboratory experiments.

The book opens with PART I, "Introductory Study of Some Simple Compounds" which contains the following chapters: Ethyl Alcohol; Some Reactions of Ethyl Alcohol; Further Reactions of Ethyl Alcohol; Analysis of Organic Compounds; Empirical Formulas; Determination of Molecular Weights and Molecular Formulas; Acetic Acid; Structure of Acetic Acid and Ethyl Alcohol. PART II takes up the study of the aliphatic compounds and PART III of the aromatic compounds, under the expected headings.

PART I is largely experimental in character and starts out in Chapter I with an experiment on the fractional distillation of alcohol followed by a brief discussion of distillation in general. An experiment on the preparation of ethyl alcohol from cane sugar comes next, followed by the study of the properties of ethyl alcohol. This leads the student to a consideration of boiling points and thermometer corrections. The following pages are devoted to a discussion of fermentation.

The second and third chapters in PART I are similarly presented, the former opening with an experiment on the action of sodium on alcohol, and the latter with an experiment on the preparation of ether. In general, the procedure just mentioned is characteristic of the whole book. An experiment is always carried out first and then the student is taught about the chemical reactions involved and the theoretical considerations.

At the end of each chapter are pertinent questions on the material covered and at the end of the book are several pages of miscellaneous questions. A brief review of the history of organic chemistry is given as the last chapter in PART III.

The author emphasizes in the preface the care that he has taken to give in the laboratory experiments details gained by actual experience. He claims that the experiments are more easily and more successfully carried out by the average student than the experiments found in many of the other elementary manuals.

The book is well written and contains excellent illustrations of the apparatus to be used in the experiments as well as of certain industrial equipment, also ten portraits of famous chemists.

In the United States few, if any, of the teachers of organic chemistry attempt to present the subject as outlined in this book. Such a plan might well be tried out in institutions where the facilities and the organization make it practical.

ROGER ADAMS

UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

How to Teach Secondary Chemistry and Allied Sciences. HATTIE D. F. HAUB, Roosevelt High School, Oakland, California. Harr Wagner Publishing Co., San Francisco, 1929. xiii + 292 pp. 14 illustrations. 19.5 cm. × 13.5 cm. $2.50.

The object of the author in writing this book, as stated in the introduction, is to help the teacher by enlivening the chemistry course and removing some of the drudgery.

Because of omissions of essential information and of a few assumptions that are hardly justifiable, one wonders how a criticism of this book should be made.

For instance: it is difficult to tell whether the chemistry course, as discussed, is intended for high-school juniors or seniors. The cost per pupil per year, a very important item in chemistry, is not given. It is questionable whether the work given in parts of the book is required of all, or of just a few of the best pupils.

The author's treatment of the following subjects—digestion, dilution, mending apparatus, stains, acids, the furniture of the laboratory and its care, the stockroom, and special topics for written work—shows that she has an exceptionally complete knowledge of both the high-school laboratory and the high-school textbook work. The discussion indicates that she realizes the importance of industrial chemistry and research. This knowledge and appreciation of chemistry should create, in her pupils, a high degree of interest and inspiration.

A list of minimum achievements expected from high-school pupils and a list of achievements expected only of the brighter pupils appear in chapter six. If chemistry is taught in the senior year of the high school, all but a very few pupils in each class should know practically everything given in both lists.

Teachers do not like to make out examinations or to correct papers, but I think that most teachers would not go so far as to reduce the drudgery of teaching by allowing each pupil to correct his own examination papers, as the author says she does. The advice to cut down the teacher's work by requiring little written laboratory work and arranging carefully the laboratory furniture, reagents, and stock is good.

Much of the material found in this book can be gotten from the ordinary high-school chemistry texts and manuals. However, any qualified, experienced teacher can find some valuable material in the book. For the teacher who lacks either experience or training, this book will be very useful.

DON C. EVANS

PARK COUNTY HIGH SCHOOL
LIVINGSTON, MONTANA

The Constitution of Sugars. WALTER NORMAN HAWORTH, D.Sc. (Manchester); Ph.D. (Göttingen); F.R.S., Professor of Chemistry and Director of the Department of Chemistry, in the University of Birmingham. Edward Arnold & Company, London (Longmans, Green & Co., New York City), 1929. viii + 100 pp. 14.75 × 23 cm. $3.40.

This book of one hundred pages entitled, "The Constitution of Sugars," is a valuable summary of the work of the author and his students on the methylation of carbohydrates and its bearing on their constitution. The results of these studies have attracted considerable attention. The formula of that fundamental biological unit, *d*-glucose, has undergone a decided revision. The methods used in the revision of the glucose formula have been extended to practically all the available sugars. From this it follows that all monosaccharides exist in two forms, the normal, which is a $<1,5>$ lactal, and the gamma, which is a $<1,4>$ lactal. The problem of the constitution of the disaccharides, which Emil Fischer was unable to solve, has been elucidated. The final proof of structure, the synthesis of disaccharides from intermediate of known structure, is, however, still lacking in all cases save one. The results of the methylation studies on the constitution of polysaccharides are still admittedly incomplete. The author has advanced a novel nomenclature and diagrammatic formulas for the carbohydrates, which are receiving considerable acceptance, particularly among the German workers in the field.

The experimental work described is of a very difficult nature, mainly because of the difficulty of obtaining crystalline substances in the methylated sugar series. The results now recorded are at last based upon the isolation of crystalline derivatives of known homogeneity and several important previous errors have through this been corrected.

The final solution of disaccharide structure has consisted mainly in the

determination of the point of attachment of the component sugars. As this is based upon the methylation of open-chain structures, it is undoubtedly correct. The structures of the reference methylated sugars is also well supported by good evidence. However, the skeptic may well doubt if the structure of the product obtained by methylation of a reducing sugar, such as glucose, truly represents the structure of a substance that is capable of existing in such a large number of tautomeric forms. The ease of lactal shift is also being further demonstrated as work in this field progresses. The complete exclusion of lactal forms other than the <1,4> and <1,5> may also become an issue later.

American chemists will be pleased to note that the writer gives full recognition to the researches of J. U. Nef on the isomeric pairs of hexonic lactones, which is so fundamental to the methods used by Haworth. The lactone rule of C. S. Hudson is also extensively employed by the author. On page 24, the important work published by P. A. Levene and H. S. Simms, in 1925, on lactone structure is omitted, although their work published in 1926 is cited.

M. L. WOLFROM
THE OHIO STATE UNIVERSITY
COLUMBUS, OHIO

Outlines of Biochemistry. ROSS AIKEN GORTNER, Professor of Agricultural Biochemistry, in the University of Minnesota, and Chief of the Division of Agricultural Biochemistry, University of Minnesota and the Minnesota Agricultural Experiment Station. John Wiley and Sons, Incorporated, New York, 1929. xv + 793 pp. 15 × 23 cm. $6.00.

This most interesting book has been dedicated by the author to his several colleagues and co-workers who have collaborated with him in his many teaching and research activities. An interesting feature is the manner in which the author begins the preface of his text This is introduced courteously by a quotation from Professor John J. Abel of Johns Hopkins University, and is evidence of the recognition which researchers in the biological sciences have for the fundamental teachings of chemistry.

A serious attempt is made by the author to introduce the student who is interested in biological phenomena to the important rôles that organic chemistry and physical chemistry play in the complicated processes of the living cell. As one who has had experience in the teaching of organic chemistry to biological students, this method of presentation is greatly appreciated. The author makes no distinction in his discussion between what he calls phytochemistry and zoochemistry reactions.

In the early development of his text, the author has laid great stress on the physico-chemical processes taking place in living cells and tissues, and he plunges at once into a complete discussion of the colloid state of matter. Here he has given a complete review of the technic of this new branch of chemistry. The properties of colloidal systems are presented clearly, and the phenomena of hydrogen-ion concentration, surface tension, surface energy, interfacial tension, and adsorption are explained and discussed clearly, and also special chapters are devoted to the fundamental distinction between electrolytes and colloid systems. Consideration is also given to the properties of gels, methods of measuring osmotic pressure, and also to a discussion of the Donnan equilibrium and its application to biological phenomena. This method of presentation is decidedly a new feature in the general method of teaching the principles of biochemistry, and forces the reader and student to give attention to special physical and chemical phenomena which many of our teachers are inclined to neglect. Any organic chemist who has had occasion to work with biological products will at once be impressed with the need of developing a technic which is dependent on a good knowledge of the colloidal nature of the material under examination. Nearly one-half of the text, 285 pages, is devoted

to the physico-chemical aspects of the subject.

The chapters comprising the text in addition to those embraced under the heading, Colloid State of Matter, are the following: Proteins, Carbohydrates and Allied Compounds, The Tannins, Plant Pigments, Fats, Lipides and Essential Oils, and the Biocatalysts. A most important feature of the book is a complete list of literature references which greatly enhance the value of the book to the research student.

This book should be on the shelf of every university chemistry library and in the possession of every researcher and teacher interested in the promotion of biochemistry. The developments in this field of science are bound to be very rapid, and undoubtedly the advances will be so great within the immediate future that the author will be called upon to prepare very soon a new edition of this text so that his book may represent an up-to-date record of the rapid progress of biochemical research. The rapid changes of thought to which we are being subjected is well illustrated by the recent work on the chemistry of the polypeptide "Glutathione."

TREAT B. JOHNSON

YALE UNIVERSITY
NEW HAVEN, CONN.

Lectures on Biologic Aspects of Colloidal and Physiologic Chemistry. W. B. Saunders Co., Philadelphia, Penna., 1927. 244 pp. 85 illustrations and 9 tables. 13.5 × 19.5 cm. $2.50.

This book constitutes a group of lectures on the biologic aspects of physiologic and colloid chemistry given during the fall and winter of 1925–1926 under the auspices of the Mayo Foundation and the local chapter of Sigma Xi at Rochester, Minnesota, the Medical School of the University of Wisconsin, Madison, Wisconsin, the Graduate School of the University of Minnesota, Minneapolis, Minnesota, the Medical School of Washington University at St. Louis, Missouri, the Graduate School of the University of Iowa, Iowa City, Iowa, and the Des Moines Academy of Medicine at Des Moines, Iowa.

The titles of the lecture and the authors are as follows:

Introduction
LOUIS B. WILSON, M.D., Director, The Mayo Foundation.

Principles Underlying Colloid Chemistry
ROBERT A. MILLIKAN, Director of the Norman Bridge Laboratory of Physics, California Institute of Technology, Pasadena, California. (10 pages in text.)

Colloid Chemistry in Biology and Medicine
MARTIN H. FISCHER, Professor of Physiology, University of Cincinnati, Ohio. (82 pages in text; 39 figures; 81 references.)

The Physical Properties of Protoplasm
ROBERT CHAMBERS, Assistant Professor of Anatomy, Cornell University, New York. (19 pages; 14 figures.)

Adsorption and Vital Phenomena
ROSS A. GORTNER, Professor of Agricultural Biochemistry, University of Minnesota, Minneapolis. (31 pages; 14 figures; 7 tables, and 17 references.)

The Physics of the Ultramicroscope and Optical Properties of Colloid Particles
E. FRANKLIN BURTON, Professor of Physics, University of Toronto, Ontario, Canada. (20 pages; 11 figures; 2 tables, and 10 references.)

The Biological Effects of Light
WILLIAM T. BOVIE, Assistant Professor of Biophysics, Harvard University, Boston, Massachusetts. (51 pages; 6 figures.)

As well-stated in the introduction, "The lectures cover a number of important aspects of recent investigation in the field of colloid chemistry from the biologic standpoint. The lecturers themselves were selected because of their original investigations in the fields concerned. The volume thus covers in an authorita-

tive manner many of the important questions in colloid chemistry of interest not only to chemists but also to physicians, biologists, and many others."

The book does just what the last sentence states, covers *many* important questions of interest to chemists, physicians, and biologists. The lectures were written with apparent enthusiasm, and the reader who understands such subject matter is sure to be enthused. The book is especially good for students of chemistry who have not yet seen the many applications of their subject matter in the field of biology.

P. W. ZIMMERMAN

BOYCE THOMPSON INSTITUTE, INC.
YONKERS, NEW YORK

Pettibone's Textbook of Physiological Chemistry. Revised and rewritten by J. F. MCCLENDON, Ph.D., Professor of Physiological Chemistry, Medical School, University of Minnesota, Minneapolis. Fourth edition. The C. V. Mosby Company, St. Louis, Mo., 1929. 368 pp. 17 figures. 14 × 21.5 cm. $3.75.

Professor McClendon has made a nice job of revising the well-known Pettibone which has been used in introductory courses of physiological chemistry for over a decade.

In the preface of the first edition occurs this statement: "My aim in writing this book has been to prepare an intermediate text which would cover the general field of physiological chemistry in such a way as to give students a familiarity with compounds important from a biological viewpoint, and to acquaint them with the fundamental processes which go on in the animal body. I have attempted to avoid confusing the beginner with lengthy discussions of debated points."

The reviewer agrees with this idea. It is of course quite essential that debated and disputed points should be considered at some time, but that time is not in a beginner's course.

Like most of the better texts, Pettibone has developed out of a course. The course in physiological chemistry at the University of Minnesota began in 1893 and seven professors have helped in shaping it. A dignified ancestry to say the least.

The outstanding feature of the fourth edition is the number of well-selected illustrations which were not in the previous editions. It is hoped that succeeding editions will contain still more diagrams, and other illustrative material.

The reviewer would like to see some other hopes fulfilled. The more modern names for carbohydrates, proteins, and fats should be used in place of or as well as the older ones. Chapter six which is headed "Some Important Foodstuffs and Some Important Tissues" might be divided in three smaller chapters: one on "Foodstuffs," another on "Tissues" and a third on "Vitamins." Each one of these topics deserves rather complete treatment. This would make the book somewhat larger but would add to its usefulness and completeness without confusing the beginner. The absorption spectra on page 115 would look much better in color. The description of a calorimeter on page 54 would be much more readily understood if a diagram were added. The laboratory work should include an exercise in determination of hydrogen-ion concentration.

The publishers have done their work remarkably well. Only one error has been discovered so far; the structural formula for amino acetic acid on page 21 is not correct, and that may not be the printer's fault.

The reviewer has used Pettibone for seven years in his introductory course of physiological chemistry, and during this time has not seen a better text. It includes the essentials of such a course for students of biology and chemistry, and, with additional lecture notes, is quite suitable for the medical and dental student.

A. P. SY

UNIVERSITY OF BUFFALO
BUFFALO, NEW YORK

The Science of Nutrition Simplified. A Popular Introduction to Dietetics. D. D. ROSEWARNE, M.R.S.C. (England),

L.R.C.P. (London), Late Honorary Actino-Therapeutist and Assistant Physician, City of London and East London Dispensary; Specialist Pathologist, R.A.M.C.; Officer in Charge, Central Military Laboratory, Port Said; Officer in Charge, Anzac Field Laboratory, Sinai, Palestine; Late Assistant Pathologist and House Physician, St. Mary's Hospital. The C. V. Mosby Company, St. Louis, Mo., 1929. viii + 314 pp. 7 figures. 13.5 × 19.5 cm. $3.50.

In the introduction, the author definitely states that his aim is the presentation of the principles of nutrition in a form so simple that they may be understood by one who has no technical knowledge of chemistry and physiology. In PART I (80 pp.) he has attempted to give those chemical and physiological facts which are absolutely required, in as simple a form as is compatible with an understanding of the subject to be presented. PART II (92 pp.) includes a discussion of the food requirements of the organism. It points out the kinds and amounts of the food constituents and accessories, that is, proteins, carbohydrates, fats, minerals, and vitamins, that are used in the life processes of man and explains the function of each. In PART III (70 pp.) the foods are divided into classes and it is shown to what extent the different classes are efficient in supplying the required food constituents and accessories for nutrition. PART IV (66 pp.) explains how a diet containing the necessary constituents in the required amounts can be calculated. For this purpose, a table giving the percentage composition of the common foods has been included.

It is probable that PART I presented the most difficult task to the author. It seems impossible that a discussion of eighty pages could include chemistry enough to be of any practical value in the understanding of a subject so complex as that of nutrition, yet the few well-chosen facts are presented in a manner which is not only interesting but sufficiently complete to allow the author to admirably accomplish the purpose ascribed to the remainder of the book.

Throughout the text the material is presented in logical sequence with sufficient repetition to correlate the several phases of the discussion without requiring the reader to master the earlier chapters. Where possible the experimental basis for the scientific results are explained and every effort made to foster confidence in, and the demand for, the scientific method. Aside from the fact that the author has presented an unbelievable amount of scientific material in so interesting, simple and lucid a manner, he has avoided those extremes which make up so much of the propaganda that is offered to the public as the truth concerning nutrition.

The plan of brevity and simplicity has led to definitions and assertions which at times are not quite technically sound but on the whole the abridgment is justified by the aim of the treatise. If the reader becomes a student of nutrition, further study will supplement his imperfect ideas. If he goes no further into the subject, he will be guided in the right direction by the general impressions that he receives.

In view of the lack of reliable material on the subject which is available to the layman, "The Science of Nutrition Simplified" should fill a very definite need.

LILA SANDS

UNIVERSITY OF ARIZONA
TUCSON, ARIZONA

BULLETINS

State School Taxes and School Funds and Their Apportionment. FLETCHER HARPER SWIFT, Professor of Education, and BRUCE LEWIS ZIMMERMAN, Research Assistant in Education, both of the University of California. *Department of the Interior. Bulletin*, 1928, No. 29. U. S. Government Printing Office, Washington, D. C., 1929. 431 pp. 15 × 23 cm. $0.50.

A report of the practices of the forty-eight states.

A Program of Educational Guidance for High Schools. E. O. BOTTENFIELD.

University of Illinois Bulletin, **27** (Oct. 1, 1929); *Educational Research Circular* No. 54, Published by the University of Illinois, Urbana, Illinois.

This *Bulletin* contains discussions on The Students and the Curriculum, A Tentative Program, and The Application of the Educational Guidance Program to Smaller and to Larger High Schools.

Annual Report of the Commissioner of Education for the Year Ended June 30, 1929. *U. S. Dept. of the Interior.* U. S. Govt. Printing Office, Washington, D. C., 1929. 50 pp. 15 × 23 cm. $0.10.

University of Kentucky Research Publications. This booklet of 50 pages published by the Research Club of the University of Kentucky contains the titles of all research papers published by its members to date. An excellent idea! Such an imposing list cannot help but stimulate research among the officers and instructors of the University.

Pure Manganese Obtained by Vacuum Distillation. Distillation gets most of its publicity as a result of its more or less disreputable employments; but it achieves most of its real usefulness in the world in technical laboratories few people ever hear about, at tasks which only chemists can think up for it. Its newest job is to get manganese, one of steel's most important alloys, out of its ores in an almost absolutely pure condition. An improved apparatus for doing this was recently described in Pittsburgh at a meeting of the Metallurgical Advisory Board, by Dr. James B. Friauf.

Distillation of any kind depends on boiling the material to be purified, and then condensing the steam or vapor. This is simple enough with water, which boils at 100 degrees Centigrade, and with alcohol, which boils at an even lower temperature. But the boiling point of manganese at atmospheric pressure is about 1900 degrees, and even in an almost complete vacuum it is still in the neighborhood of 1000.

To accomplish this difficult distillation, Dr. Friauf encloses a magnesia crucible full of manganese ore in a chamber of fused silica. Around the crucible is a coil of water-cooled wire, through which a high-tension, high-frequency alternating current is passed. This induces what are known as "eddy currents" within the coil and this induced electricity heats the manganese in the ore above its boiling point, causing it to pass off as a vapor. The gaseous manganese rises from the crucible through a magnesium chimney, and condenses into a solid again on its cooler walls. From there it is recovered as a solid metal, so hard that it can scratch glass.—*Science Service*

Theory of Spontaneous Combustion. Dr. Charles A. Browne, of the U. S. Dept. of Agriculture, holds the theory that the process of spontaneous combustion is both bacterial and chemical.

Describing conditions in a haystack which catches fire, he points out that first of all bacterial action causes fermentation. This heats the hay but not enough to cause ignition, for at 150 degrees Fahrenheit the bacterial process is mostly destroyed by heat, and 600 degrees would be necessary for ignition. His theory is that a chemical process enters the situation. The bacteria produce gases, and as the haystack is heating, the gases press out from the centers of chemical activity and form channels in the hay. When a channel reaches the surface of the stack, air rushes in suddenly, and the hot, unsaturated products are oxidized and the temperature rises to such a point that fire is readily produced.

A conference to discuss the facts, clues, and unknown quantities in the case regarding spontaneous combustion was held by the National Fire Protection Association in coöperation with the U. S. Departments of Agriculture and Commerce, in Washington, November 14th and 15th.—*Science Service*